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Liquidity, Technological Opportunities, and the Stage Distribution of Venture Capital Investments

Henry Lahr and Andrea Mina*

This paper explores the determinants of the stage distribution of European venture capital investments from 1990 to 2011. Consistent with liquidity risk theory, we find that the likelihood of investing in earlier stages increases relative to all private equity investments during liquidity crisis years. While liquidity is the main driver of acquisition investments and, to some extent, of expansion financings, technological opportunities are overall the main driver of early and late stage venture capital investments. In contrast to the dotcom crash, the recent financial crisis negatively affected the relative likelihood of expansion investments, but not of early and late stage investments.

Venture capital (VC) is an effective market-based solution for investment in high risk and opaque projects as it combines financial resources with specific screening, monitoring, and certification skills (Chan, 1983; Sahlman, 1990; Megginson and Weiss, 1991; Lerner, 1995; Hellman, 1998; Kaplan and Strömberg, 2001; Ueda, 2004; Caselli, Gatti, and Perrini, 2009) and with substantive knowledge of markets and technologies (Cohen and Levin, 1989; Kortum and Lerner, 2000; Cornelli and Yosha, 2003; Denis, 2004).¹ Capital flows in this market, however, have displayed sensitivity to past performance and cyclical patterns over time (Gompers and Lerner, 2000; Kaplan and Schoar, 2005). Furthermore, turmoil in international financial markets can affect the demand and supply of VC, alter the routes of capital flows across nations and financial intermediaries, and change allocation decisions between asset classes. Having shaken the foundations of the global financial system, the recent crisis has tested the resilience of VC markets and raised questions about their reliability as a funding mechanism.²

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¹ We define private equity as independently managed, dedicated pools of capital focused on equity or equity-linked investments in privately held companies. We use the term *private equity* in a broad sense to include VC funds, as well as buyout, turnaround, and mezzanine funds. VC funds are defined as those funds that invest in firms at the seed, early, or later stage of the firm's development. For a more detailed definition, see the description of Table 1.

² Fundraising by European private equity firms dropped to one-third of precrisis levels in 2009 according to Thomson ONE data. VC fundraising as a subset of the private equity market declined more slowly, but remains depressed at half its

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From a theoretical viewpoint, the crisis provides an excellent opportunity to revisit and further develop theories that explain the role of exits in VC contracting (Black and Gilson, 1998; Aghion, Bolton, and Tirole, 2004) and predict the stage distribution of private equity investments (Gompers, 1995; Cumming, Fleming, and Schwienbacher, 2005, 2009). Liquidity risk theory posits that investors face a trade off between liquidity risk and technological risk, and are more likely to invest in earlier stages in times of liquidity crises. Large time series variations in the market for new equity issues induced by the financial crisis allow us to disentangle the liquidity explanation for the stage distribution of investments from competing hypotheses derived from other macroeconomic factors. In particular, by incorporating insights from the economics of innovation, we uncover the role of technological opportunities in driving investment stage choices. From an empirical viewpoint, the crisis calls for an in-depth analysis of the long-term development patterns of the sector to deepen our understanding of its challenges and future prospects (Kedrosky, 2009; Mason, 2009; Lerner, 2011).

In this paper, we are interested in structural changes in the stage distribution of investments. We investigate the relative importance of exit channel liquidity in private equity investments at different stages of a firm's development. Our analysis focuses on the time variation in investors' choices of early versus late stage investments in relation to the broader macroeconomic framework and identifies the drivers of investment stage distribution. We posit that investors' choices will be sensitive to liquidity risk and the availability of technological opportunities. We expect to find different effects depending on market conditions and across investment stages. We test the explanatory power of liquidity and technological opportunities as drivers of the stage distribution of private equity investments. In our empirical analyses, we use information on 35,240 European private equity investments in the period 1990-2011, extracted from Thomson Reuters' private equity database, which we augment with macroeconomic indicators from Eurostat and other sources. A focus on investments, as opposed to fundraising activities or fund returns, addresses the link between financial intermediaries and the real economy.

Consistent with liquidity risk theory, our results demonstrate a greater likelihood of investing in earlier stages relative to all private equity investments during crisis years. However, liquidity risk theory cannot explain the decreasing likelihood of late stage investments in liquid markets, which we find after controlling for deal characteristics and other environmental variables. While liquidity seems to be the main driver of acquisition investments and, to some extent, of expansion financings, technological opportunities are the most powerful explanation of earlier stage investment choices. Firms' expenditures for research and development explain about half of the added log-likelihood in models for early and late stage investments when compared to full models including time dummies. Results indicating relatively weaker explanatory power for liquidity risk are supported by direct comparisons of the proportions of early and late stage investments in periods before and after the financial crisis and the dotcom crash.

This analysis responds to the need for a better understanding of long-term regularities in the stage allocation of VC. It also allows us to look at the specific effects of the financial crisis on VC-backed entrepreneurial processes, whose earlier stages may be especially resource constrained, and to verify which types of investments have been most affected and in what way. Overall, our results document a decreasing number of investments after 2003, but a reverse trend for early and late stage VC investments during the recent crisis. The crisis' effect on seed investments is, however, negative after controlling for deal characteristics and macroeconomic variables. We argue that the positive residual effect of the crisis on late stage investments, which is at odds with

precrisis volume. Similarly, investments into European target firms plunged to levels last seen after the Internet bubble burst around the year 2001.

the liquidity risk hypothesis, can be interpreted as an indication that investors are trying to keep portfolio companies afloat while waiting for exit markets to recover.

In summary, our paper contributes to the literature on the driving forces behind VC investments by testing the liquidity risk hypothesis and integrating the effect of technological opportunities and other key macroeconomic indicators. While Black and Gilson (1998) argue for the theoretical importance of exit opportunities to solve governance problems in VC, Gompers et al. (2008) empirically confirm the positive relationship between public market valuations and liquidity signals and total VC investments, but do not distinguish investments by stage. This is done by Cumming et al. (2005), who find relatively more early stage investments than late stage investments in times of illiquid exit markets. A later paper by Cumming et al. (2009) reveals a different pattern in investors' behavior. Funds shift their stage focus from early stage to later stages in a falling market. Our study examines and extends these results in the light of the financial crisis as a liquidity crisis. While prior studies posit theoretical differences between early stage and late stage VC, we find that these two stage classes behave similarly with respect to exit channel liquidity, but rather differently from other private equity stages (i.e., expansion and acquisition). By considering the full range of private equity stages, we answer the question as to which stages are most affected by liquidity that was left open by Gompers et al. (2008). We develop Gompers and Lerner's (1999) suggestion that VC accumulates in regions with high industrial and academic research and development (R&D) expenditures, and uncover strong and positive effects of technological opportunities on VC investments. Finally, we integrate into our analytical setting the sensitivity of investment stage choices to macroeconomic uncertainty and credit market conditions.

The paper is structured as follows. In the next section, we present the relevant theoretical background and derive testable hypotheses. Section II contains data sources, variables, and methods of analysis. In Section III, we present univariate statistics on the long run trends of European VC markets. Section IV provides our main results, which are further discussed in Section V in relation to the financial crisis. Section VI extends our analysis to consider the role of country-specific effects. We conclude by summarizing the main contributions of the paper and by reflecting on the long-term challenges of the VC investment model.

I. Theory and Hypotheses

The market climate for initial public offerings (IPOs) is often cited, theoretically and empirically, as the main determinant of VC investments (Black and Gilson, 1998; Gompers et al., 2008). The profitability of initial investments relies on successful exits to distribute the proceeds to the fund's investors before the end of the fund's lifetime, typically within ten years. The expectation is that during periods of narrow IPO markets, we will observe fewer late stage deals as these rely on the possibility of floating the portfolio firm within a short time after the investment. For seed and early stage investments, exit channels can be equally important, although there is a recent trend toward longer holding periods that sometimes exceed the fund's lifetime.³

In a study of liquidity risk in VC markets, Cumming et al. (2005) theorize that in times of actual or anticipated illiquidity, venture capitalists invest relatively more often in early stage deals in order to exit much further in the future. They argue that fund managers trade off this exit risk for technological risk by investing in less mature businesses that will take longer to generate profits through successful exits. These investments are realized when markets become

³ IPO valuations appear to have a positive effect primarily on the volume of new funds raised by private equity firms (Gompers and Lerner, 1999; Jeng and Wells, 2000) and especially by younger firms (Kaplan and Schoar, 2005).

more liquid and favorable to IPOs. When this happens, private equity funds target late stage investments that require little time for a profitable exit, thus reducing the proportion of early stage deals. Therefore, we would expect to see more early stage investments and fewer late stage deals in market downturns and illiquid periods.

The financial crisis exposed capital markets to a severe liquidity shock. After a substantial drop in 2009, European VC exit volume declined further in 2010. Data from the European Private Equity and Venture Capital Association indicate that while buyout exit volume (but not numbers) recovered from the crisis, VC exits remain flat since 2008, with many investments still being written off. The exit channel via IPO remains narrow, with only 22 European venture-backed companies going public in 2010, 18 in 2011, and 8 in 2012 (EVCA, 2012, 2013). This underscores the difficulties faced by VC funds when they take firms public instead of pursuing other more indirect exit routes. Econometrically, the high volatility in IPO markets and other macroeconomic variables offers an opportunity to obtain precise estimates of the effects on the otherwise slowly moving distribution of VC investments.

A time-varying stage distribution of investments can also be explained by changing investment styles. Changing market conditions may cause fund managers' preferences for early or late stage investments to drift away from the stage focus stated in the fund's partnership agreements. Cumming et al. (2009) investigate this stage drift and report statistically and economically significant effects of market conditions on the likelihood that a fund makes investments in firms at a stage of development that is inconsistent with the fund's stated stage preference at the time of its inception. Positive NASDAQ returns reduce the likelihood of stage drift in early stage funds suggesting that private equity firms try to reap the benefits of long-term investments that can be profitably sold by taking portfolio firms public. Similarly, the stage focus of late stage funds is more likely to drift into early stage in a positive market climate. Applied to periods of negative market returns and assuming that the composition of active private equity funds is stable, their results imply a smaller number of early stage investments and an increase in late stage deals.

We sum these liquidity effects to formulate the following hypotheses:

H1: A liquidity crisis increases the likelihood of seed and early stage investments.

H2: A liquidity crisis decreases the likelihood of late stage investments.

The likelihood of exit is, however, not the only factor affecting VC investment decisions, despite the central role it plays in a liquidity risk framework as developed by Cumming et al. (2005). VC investments are sensitive to stock market demand for new firms, but also respond to the availability of technological opportunities. Without underestimating the complexities of technical change (Kline and Rosenberg, 1986), historians of technology have long argued that entrepreneurial developments significantly depend upon scientific and technological progress (Rosenberg, 1974). Schumpeterian economics has demonstrated the fundamental importance of innovation for the growth of firms, industries, and national economies (Schumpeter, 1934; Nelson and Winter, 1982; Fagerberg, Mowery, and Nelson, 2005) and new growth theories have successfully incorporated the accumulation of knowledge into modern macroeconomic modeling (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992).

Technological opportunities can be loosely defined as "the likelihood of innovating" (Breschi, Malerba, and Orsenigo, 2000) or more precisely defined within a standard neoclassical theory of production as "the set of production possibilities for translating research resources into new techniques of production that employ conventional inputs" (Cohen, 2010). The magnitude of technological opportunities depends upon the nature of technological fields, their evolution over time, and their closeness to basic science (Nelson and Winter, 1982). From an aggregate viewpoint, the richer the stock of ideas circulating in the economy, the greater the probability of

new combinations of intangible inputs, their translation into production, and, ultimately, higher growth rates (Weitzman, 1998; Olsson, 2005). New knowledge opens up fresh opportunities for profit. These opportunities, which are highest at the early stages of industry or market segment development, require selective investments for the commercial exploitation of valuable ideas (Shane and Venkataraman, 2000). This is where VC can intervene to realize the potential value of new ideas, enable new firm creation, and de-risk entrepreneurial initiatives.

In the VC literature, Gompers and Lerner (1999) find that VC tends to accumulate in regions with high industrial and academic R&D expenditures. More recent data from Eurostat suggest that businesses in Europe reduced or even stopped their R&D projects in the aftermath of the dotcom bubble leading to a decrease in aggregate R&D spending as a percentage of gross domestic product (GDP) until 2005 when the trend reversed.⁴ The prospects for early stage investments during the financial crisis look more favorable from an R&D point of view. R&D expenditures rose beyond the peak reached at the height of the dotcom boom. Given the importance of technological opportunities in the early stages of new company development, we conjecture that:

H3: The effect of technological opportunities on the likelihood of seed and early stage investments is stronger than the effect of exit opportunities.

H4: The effect of technological opportunities on the likelihood of late stage investments is weaker than the effect of exit opportunities.

II. Data Sources and Methodology

A. Investment Data and Deal Variables

For our analyses of investment stages, we extract a set of 37,821 investment transactions from 1990 to 2012 from Thomson Reuters' private equity database (formerly VentureXpert). Since at the time of writing, R&D data are available only until 2011, our multivariate analyses are limited to 35,240 investments. Transaction data cover all European countries in which at least one private equity investment is observed within the period of study. For our multivariate analysis, we include countries with at least 100 investments.⁵ We include all stages of firm development (see Table I for stage definitions) except "VC partnership," as private equity funds investing in other private equity funds are beyond the scope of this paper. Following a similar rationale, we exclude financial firms as targets. In order to make meaningful comparisons over time and across countries, we adjust individual deal sizes (i.e., amount invested) for inflation and translate these values into euros according to the 2010 purchasing power parity exchange rate. Exchange rates and GDP deflators are obtained from the International Monetary Fund (IMF) World Economic Outlook Database April 2013.

The portfolio company and deal-specific variables we use in our analyses include the target firm's geographical location (nation), industry, firm age at investment, type of capital provided (equity, debt, or both), and the number of investors. Industries are coded according to the 10 US Standard Industry Classification (SIC) 1987 divisions. An overview of the sample composition can be found in Table I. Because of the highly skewed age distribution, we use the logarithm of firm age in days at the investment and the logarithm of deal size in all our analyses. The mean

⁴ Total R&D expenditure (GERD) in the European Union (27). Time series (code: rd_e_gerdtot) are available from Eurostat at http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.

⁵ The final list contains Austria, the Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, the Netherlands, Norway, Poland, Romania, Spain, Sweden, Switzerland, and the United Kingdom.

Table I. Summary Statistics for Key Variables

This table presents descriptive statistics for the main variables used in this paper. *Age* is measured as firm age in (log) days at investment. *Deal size (log)* is adjusted for inflation using the local GDP deflator and converted to EUR based on 2010 purchasing power parity exchange rates (source for GDP and PPP data: IMF World Economic Outlook 2013). *Investors* is the (log) number of investors in a transaction. *IPOs Europe* is the (log) number of European firms going public in the calendar year in which the investment is made. *R&D/GDP* is aggregate R&D spending for EU27 countries by GDP in percentage points, *VIX* is the CBOE volatility index divided by 100, *ESI* is the European Economic Sentiment Indicator divided by 100, *UK Credit Spread* is the yield spread between 10-year UK gilts and UK 10-year corporate bonds from Datastream, and *UK Gov. Yield* is the yield on 10-year UK gilts, both in percentage points. Stage definitions are as follows: *Seed Stage* is the investments in portfolio companies that have not yet fully established commercial operations. These may also involve funding for research and product development. *Early Stage* is the provision of finance for product development and initial marketing, manufacturing, and sales activities. *Later Stage* involves firms that have an established product or service, which may not be making a profit yet. Late stage rounds include the last round of investments in portfolio companies before an exit by an IPO or trade sale is made. This category includes bridge loans. *Expansion* includes investments by both buyout firms and venture capital firms. For venture capital firms, expansion investments in firms with established products and services are used to expand production and increase revenue. For buyout firms, these investments are sometimes referred to as growth investments. The objective of these investments is to expand operations nationally or internationally by increased production or through acquisitions of smaller or similarly sized firms. *Acquisition* includes transactions used to obtain control of a private portfolio company, such as a leveraged buyout (LBO), management buyout (MBO), management buy-in (MBI), mezzanine capital, secondary buyout, or an acquisition for expansion. *Other*: This category includes public market investments (open market purchases or PIPEs—a private placement of equity by companies that are already trading on the public market), recap transactions, turnaround investments and secondary purchases.

	N	Mean	Median	SD	Min	Max	% Missing
<i>Panel A. Deal Characteristics</i>							
Age (log)	35,240	7.806	7.819	1.441	0.000	11.450	23.1
Deal Size (log)	35,240	0.875	0.932	1.918	-8.696	8.634	33.0
Investors (log)	35,240	0.343	0.000	0.517	0.000	3.091	0.0
Capital Type	Equity	46.4%	Equity & Debt	1.8%			
	Debt	2.4%	Missing	49.2%			
Stage	Seed	9.6%	Later Stage	6.1%		Acquisition	31.5%
	Early Stage	14.5%	Expansion	33.9%		Other	2.2%
Industry	Construction	1.4%	Retail trade	3.7%		Missing	22.7%
	Infrastructure	6.3%	Services	30.8%			
	Manufacturing	31.6%	Wholesale trade	3.4%			
Country	Austria	1.4%	Hungary	0.6%		Romania	0.4%
	Belgium	2.5%	Ireland	2.4%		Spain	4.4%
	Czech Republic	0.5%	Italy	2.9%		Sweden	6.7%
	Denmark	3.2%	Netherlands	4.9%		Switzerland	2.4%
	Finland	4.1%	Norway	2.1%		United Kingdom	27.6%
	France	19.0%	Poland	1.4%			
	Germany	12.4%	Portugal	1.1%			
Year	1990	0.3%	1996	1.5%	2002	5.0%	2008 6.2%
	1991	0.3%	1997	1.3%	2003	9.2%	2009 4.2%
	1992	0.4%	1998	2.5%	2004	9.9%	2010 5.6%
	1993	0.5%	1999	4.5%	2005	8.8%	2011 6.9%
	1994	0.6%	2000	9.5%	2006	7.3%	
	1995	0.8%	2001	8.1%	2007	6.5%	

(Continued)

Table I. Summary Statistics for Key Variables (*Continued*)

	<i>N</i>	<i>Mean</i>	<i>Median</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	<i>% Missing</i>
<i>Panel B. Macroeconomic Indicators</i>							
IPOs Europe	35,240	5.912	5.900	0.588	3.912	6.834	0.0
R&D/GDP	35,240	1.193	1.190	0.038	1.093	1.270	0.0
VIX	35,240	0.214	0.225	0.060	0.124	0.327	0.0
ESI	35,240	1.020	1.026	0.078	0.793	1.145	0.0
UK Credit Spread	35,240	1.340	1.129	0.956	0.368	4.382	0.0
UK Gov. Yield	35,240	4.784	4.883	1.056	3.121	11.803	0.0

(log) age is 7.8 days (approx. 6.7 years), while without taking logs, mean age is 16 years. The median deal size is EUR 2.6 million, but its average is EUR 17 million. The average investment has 1.7 investors. A large majority of investments are made in the form of equity, and only a tiny minority involve the provision of debt or a mix of equity and debt.

An important consideration in our analysis is the representativeness of our sample. The data obtained from Thomson ONE may contain errors or biases toward late stage deals that might skew our results. Kaplan, Sensoy, and Strömberg (2002) and Maats et al. (2008) provide comparisons and discussions of the most popular data sets. Kaplan et al. (2002) report that about 15% of investments made from 1986 to 1999 are missing in Thomson ONE (Thomson Venture Economics) and VentureSource. While both databases record financing amounts with substantial noise, they tend to be unbiased. Thomson ONE was found to be biased toward larger, California-focused investment rounds. Maats et al. (2008) conclude that consistency between the databases is low, but higher on the investment level than on the fund level. Although none of these studies provide insight into selection biases with respect to the stage of investments, nonselection of seed or early stage deals can be a problem if rounds are too small to be recorded by ThomsonOne. We address this risk by conducting a propensity score matching analysis of post- and precrisis investments. Matching over a short period around event dates helps to safeguard against the risk of sampling bias, whose impact, if at all present, should be negligible in time comparisons over short horizons.

B. Macroeconomic Variables

Following Cumming et al. (2005), we proxy for liquidity risk by using the (log) number of European IPOs (EU27 countries) in the year the investment is made. IPO data are obtained from Thomson ONE. In our test of alternative indicators for liquidity risk, we use the global number of IPOs and the global number of private equity-backed IPOs, as these should be closely related to exit opportunities. All these liquidity proxies have one limitation: Even though they exhibit a large time variation, they are nonstationary in principle. This may be a problem if we try to predict a stationary variable. Ideally, we would like to use a variable that measures the global propensity of private equity-backed firms to go public. Unfortunately, the global number of firms with private equity backing in a given year is not known with reasonable precision. Therefore, we scale the number of IPOs in Europe and in the world by the total number of domestic firms listed on European or global stock exchanges, respectively, to perform a robustness check on our main regressions.⁶

⁶ Note that in the European case, this calculation is different from taking first differences of the total number of listed firms since European firms might list their stock on an international exchange not located in Europe.

Operationalizing the concept of technological opportunities poses its own difficulties (Cohen, 2010). Theoretically, it could be treated as the amount of technical advance per unit of R&D and quantified by changes in product quality, variety, and the introduction of new products or services (Griliches, 1979). Patents or citation-weighted patent counts have been used as retrospective measures of technological opportunities (Jaffe, 1986, 1988; Trajtenberg, 1990) although patents are themselves output, not input, of inventive efforts. Technological opportunities could be conceived of as a latent and unobserved construct (Geroski, 1990) with several dimensions, including the contribution of different sources of knowledge internal and external to the firm (Cohen, Levin, and Mowery, 1987; Cohen and Levinthal, 1989). The literature presents a nuanced treatment of the relationship between different constituent components (Cohen, 2010), but overall empirical research has shown that most of the construct's dimensions tend to closely correlate with R&D expenditures (Nieto and Quevedo, 2005). Although the contribution of scientific and technological progress to innovation varies across industries (Scherer, 1965; Klevorick et al., 1995), and the type and efficiency of search processes may vary over time (Dosi, 1988; Olsson, 2005), R&D expenditures are a good proxy for the aggregate volume of technological opportunities in the context of our study also as VC is highly concentrated in R&D intensive sectors and its long run evolution displays similar cyclical patterns. As our indicator for technological opportunities, we use aggregate expenditures for research and development by business in the European Union (27 countries), scaled by aggregate GDP. R&D and GDP data are obtained from Eurostat.⁷

Since private equity investments are structured differently across stages, there is reason to believe that changes in macroeconomic variables other than liquidity and technological opportunities affect early stage investments in a different way than expansion or buyout transactions. A tightening of credit markets, for example, will have a larger impact on debt-heavy buyout investments than on VC equity financing. To account for these effects on the stage distribution, we test a range of indicators for economic uncertainty and credit market conditions. The attractiveness of new investments can be affected by factors that have an impact on cash flows and capital costs in portfolio companies. We use the annual average of the European Sentiment Indicator (ESI) to proxy for anticipated demand conditions.⁸ This indicator is composed of the Industrial confidence indicator (weight 40%), the Services confidence indicator (30%), the Consumer confidence indicator (20%), and the Retail trade and Construction indicators (both 5%). The annual European GDP growth rate can be seen as another indicator for firms' growth potential. Due to its high correlation with the sentiment indicator ($\rho > 0.9$), however, we focus our analysis on ESI, since it also captures the forward-looking dimension of firms' product market activities.

The CBOE Volatility Index (VIX) can also be used as an indicator of uncertainty about firms' prospects and stock returns as increasing volatility represents a deterioration of investment opportunities. Implied option volatility has been tested in the literature as an investor sentiment indicator (Baker and Wurgler, 2007) or fear gauge (Whaley, 2000). Campbell and Hentschel (1992) estimate a model in which increases in expected excess stock returns are driven by increasing volatility and find that this effect is concentrated in periods of high volatility. Measures for volatility risk and investor sentiment predict stock returns in the cross-section (Ang et al., 2006) and are negatively related to aggregate returns and stock fund flows (Simon and Wiggins, 2001; Kurov, 2010). These findings suggest that increases in stock market volatility raise expected and actual stock returns, thus lowering stock prices. If firms at different stages of development are unequally affected by changes in aggregate volatility, we expect to see a change in the stage

⁷ Available at http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database, time series code: rd_e_gerdtot.

⁸ Available at http://ec.europa.eu/economy_finance/db_indicators/surveys/index_en.htm.

distribution of investments. To test the effect of volatility on the stage distribution, we use yearly averages calculated from daily VIX data.

Hahn and Lee (2006) argue that credit spread proxies for credit market conditions and find that small stocks have higher loadings on credit spread than large firms. They determine that changes in credit spread capture information contained in the Fama-French (1993) size and book-to-market factors. We calculate credit spread as the difference between the yield of a 10-year UK corporate bond and a 10-year UK government bond. Ideally, we would like to use an aggregate measure for the European bond market. However, the introduction of the euro and the absence of long time series for European corporate bonds make it impossible to calculate a credit spread measure for European countries other than the United Kingdom. Corresponding to this choice for credit spread, the 10-year UK government bond yield serves as a measure for the interest rate level. Since bond yields for UK and other European bonds are highly correlated over the period of study, we are confident that the error involved in the choice of a different regional scope is negligible.

Table II presents the key summary statistics of our data by investment stage. As expected, it reports that, on average, the seed and early stage involves younger firms, smaller deal sizes, and fewer investors than the later stages. Expansion and acquisition investments (“other stages” in the table) involve the largest deals and the lowest number of investors. These summary statistics hint at a key hypothesis of the paper by demonstrating a higher R&D intensity for seed, early, and late stage investments relative to the other stages. In addition, deals at the later stage occur at relatively higher values for volatility and credit spread, and at lower values of market confidence in a univariate setting.

C. Estimation

We test the liquidity risk hypotheses in two different settings. First, we test the overall explanatory power of exit channel liquidity to explain the stage distribution of investments in logit models that predict the likelihood that an investment is made in a specific stage category relative to all other private equity stages. Since we cannot be sure that there is a strict order of investment stages across the whole spectrum (e.g., a firm can be in an expansion phase before or after a late stage VC investment), we estimate individual logit models instead of ordered discrete response models. For ease of interpretation, stages are estimated individually, but we also discuss unreported findings of a multinomial regression. In a first set of models, we incorporate time dummies to capture the aggregate effect of macroeconomic factors on each yearly cross-section. The fit of these models serves as a benchmark for a second set of models that tests the effects of liquidity risk and other variables, replacing the time dummies in the first set of regressions. Estimations employ Huber-White heteroskedasticity-robust (HC3) standard errors, and all our main results are robust to clustering by year and industry.

Additionally, we treat the financial crisis as a natural experiment on the effect of a market shock on investment stage choice. We isolate a period of large changes in liquidity during the financial crisis and test the crisis’ treatment effect on the stage distribution of VC investments. We match investments before and after the onset of the financial crisis, which we select to be January 1, 2008, and compare the proportion of deals in each stage category. Investments within a two-year and three-year period after this date are defined as “treated” observations, for which we identify a matching “control” observation in the three-year period before the event. We match investments by country, industry, and type of capital received and use propensity score matching on age, deal size, industry, country, number of investors, and type of capital in each cell so defined. Results are presented in standard unweighted form and weighted by deal size in order to assess their

Table II. Summary Statistics by Investment Stage

This table presents descriptive statistics for the main variables by investment stage and compare means, medians, and proportions between stages for our main independent variables. Stage definitions correspond to those in Table I. For conciseness, we present the main groups of interest, *Seed & Early* stage investments, *Later Stage* and *Other Stages*, where *Other Stages* comprises expansion investments, acquisitions and other private equity investments as defined in Table I. We compare means using Student's *t*-test, medians by employing Fisher's exact test for testing the null of independence of rows and columns in a contingency table with fixed marginals (after splitting the combined sample at the median), and proportions in dummy variables through Pearson's chi-squared test.

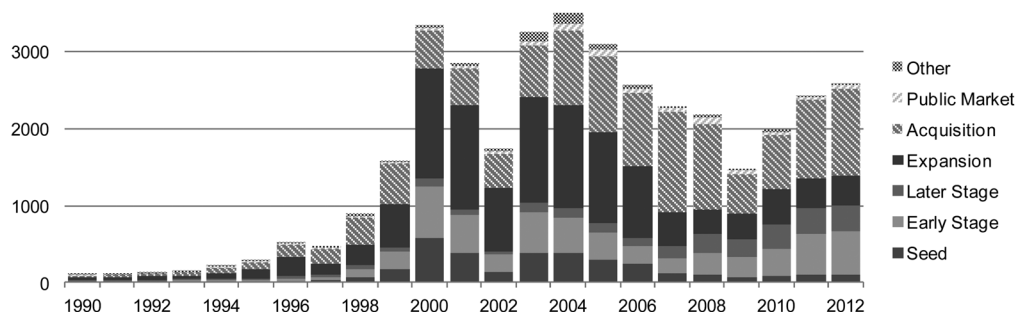
<i>Panel A. Comparisons of Means</i>						
	Mean			Stage Comparisons		
	Seed & Early	Later Stage	Other Stages	Seed & Early vs. Late	Seed & Early vs. Other	Later Stage vs. Other
Age (log)	6.587	8.181	8.185	−57.550***	−83.569***	−0.148
Deal Size (log)	0.220	0.675	1.205	−9.392***	−33.298***	−11.354***
Investors (log)	0.370	0.434	0.326	−4.500***	6.702**	8.083***
IPOs Europe	5.951	5.767	5.911	12.664***	5.203***	−10.778***
R&D/GDP	1.196	1.211	1.190	−15.349***	11.729***	21.840***
VIX	0.218	0.231	0.211	−8.939***	9.449***	14.257***
ESI	1.025	0.994	1.021	14.662***	3.864**	−13.664***
UK Credit Spread	1.295	1.822	1.314	−18.760***	−1.659*	18.806***
UK Gov. Yield	4.773	4.425	4.820	12.994***	−3.578***	−15.571***
<i>Panel B. Comparisons of Medians</i>						
	Median			Stage Comparisons		
	Seed & Early	Later Stage	Other Stages	Seed & Early vs. Late	Seed & Early vs. Other	Later Stage vs. Other
Age (log)	6.780	8.169	8.143	$p \leq 0.000$ ***	$p \leq 0.000$ ***	$p = 0.230$
Deal Size (log)	0.349	0.783	1.252	$p \leq 0.000$ ***	$p \leq 0.000$ ***	$p \leq 0.000$ ***
Investors (log)	0.000	0.000	0.000	$p \leq 1.000$	$p \leq 1.000$	$p \leq 1.000$
IPOs Europe	5.900	5.820	5.900	$p \leq 0.000$ ***	$p \leq 0.000$ ***	$p \leq 0.000$ ***
R&D/GDP	1.200	1.220	1.190	$p \leq 0.000$ ***	$p \leq 0.000$ ***	$p \leq 0.000$ ***
VIX	0.233	0.233	0.224	$p \leq 0.141$	$p \leq 0.000$ ***	$p \leq 0.000$ ***
ESI	1.026	1.008	1.026	$p \leq 0.000$ ***	$p \leq 0.002$ ***	$p \leq 0.000$ ***
UK Credit Spread	1.129	1.285	1.129	$p \leq 0.000$ ***	$p \leq 0.930$	$p \leq 0.000$ ***
UK Gov. Yield	4.883	4.503	4.883	$p \leq 0.000$ ***	$p \leq 0.000$ ***	$p \leq 0.000$ ***
<i>Panel C. Comparisons of Proportions</i>						
	Proportion			Stage Comparisons		
	Seed & Early	Later Stage	Other Stages	Seed & Early vs. Late	Seed & Early vs. Other	Later Stage vs. Other
Age n/a	0.312	0.143	0.309	$p \leq 0.000$ ***	$p \leq 0.576$	$p \leq 0.000$ ***
Deal Size n/a	0.398	0.253	0.546	$p \leq 0.000$ ***	$p \leq 0.000$ ***	$p \leq 0.000$ ***
Equity	0.580	0.584	0.417	$p \leq 0.789$	$p \leq 0.000$ ***	$p \leq 0.000$ ***
Debt	0.009	0.145	0.018	$p \leq 0.000$ ***	$p \leq 0.000$ ***	$p \leq 0.000$ ***
Equity & Debt	0.013	0.018	0.020	$p \leq 0.106$	$p \leq 0.000$ ***	$p \leq 0.660$

***Significant at the 0.01 level.
 **Significant at the 0.05 level.
 *Significant at the 0.10 level.

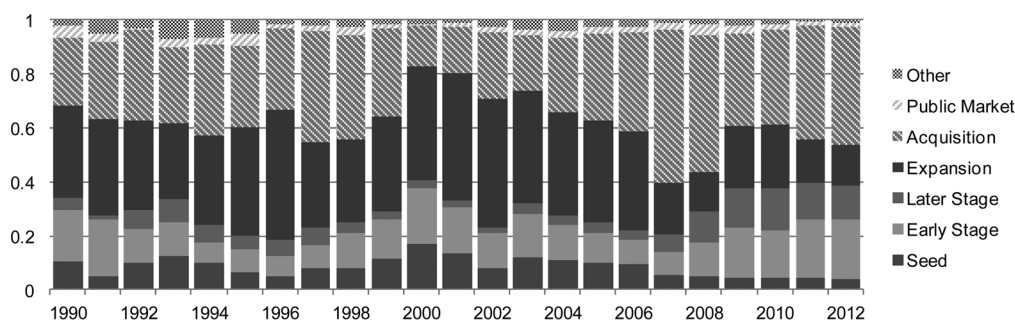
Figure 1. Number of Private Equity Investments by Stage

This graph includes 37,831 investments in European targets from 1990 to 2012. Deals involving target firms in the financial sector have been excluded.

Investments



Proportion



economic significance. The crisis' effect can then be compared with the effect of the economic downturn after the dotcom bubble, the date of which we identify with the peak of the NASDAQ Composite index on March 10, 2000.

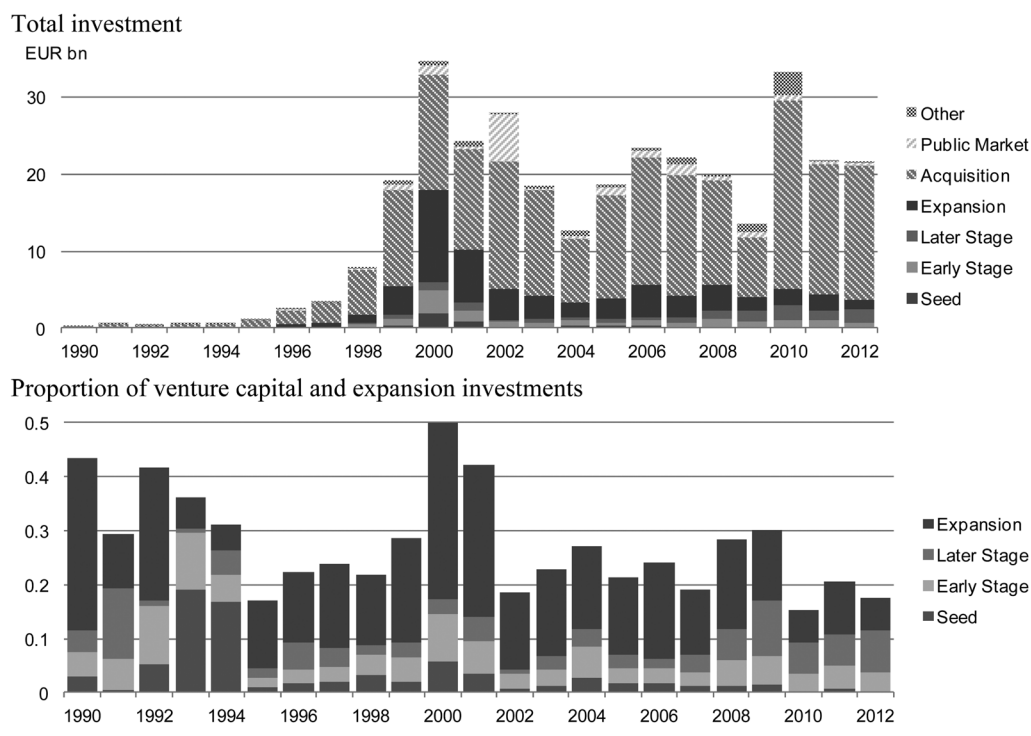
Missing values are frequent in our data. Since firm age is not available for about one-third of our observations, we include a dummy variable to indicate a missing age observation and set firm age to zero for these cases. We also construct an indicator for missing deal size, which is not available for about half of all investments. This indicator is the same as our indicator for missing financing information since this information is missing if, and only if, deal size is missing.

III. Stage Trends

Comparisons across time indicate a trend toward larger deals, primarily driven by the buyout sector. The total number of private equity investments has been steadily decreasing prior to the financial crisis after the postdotcom peak in 2004 (see Figure 1). The financial crisis hit private equity markets in late 2008, when fundraising activities came to an almost complete halt and

Figure 2. Volume of Private Equity Investments by Stage

This graph includes 37,831 investments in European targets from 1990 to 2012. Deals involving target firms in the financial sector have been excluded. Deal sizes are adjusted for inflation and converted into 2010 PPP euros. The lower graph excludes acquisitions and other investments to show the composition of earlier stages more clearly.



investments were cancelled or deferred. Investments picked up again after the dip in 2009, and have been in line with the general trend prior to the crisis since then. There was a similar period of low activity in 2001 and 2002, with the number of investments dropping even stronger. Deal numbers grew back to precrisis levels within three years both after the dotcom bubble and the financial crisis. In terms of deal volume, however, recovery took much longer after the dotcom bubble (see Figure 2). The quick recovery appears to be driven by buyout/acquisition deals, whose euro volume rose quickly and stabilized on precrisis levels after the immediate liquidity shocks had subsided in 2010.

This uneven development is particularly striking when comparing the proportion of investments in each stage category. The proportion of VC investments, including expansion investments, has remained roughly constant since 2009, as shown in the lower panels of Figure 1. However, the relative volume of these investments dropped sharply in 2010. This picture is, of course, just the reverse of the buyout deals' strong comeback after 2009, but it strongly suggests that the financial crisis might have affected the private equity market's subsectors quite differently.

If we compare yearly stage distributions in the postcrisis and postbubble periods, we find a strong shift toward later stage and buyout deals. While late stage VC deals were almost nonexistent around the year 2000, they now constitute a substantial proportion of private equity investments. According to Thomson ONE's definition, late stage deals can be VC investments in established, yet unprofitable, businesses or the last round before an exit is made through an IPO or trade sale. Many of them are follow-on investments in existing portfolio companies. EVCA (2013) data indicate that 55% of all private equity investments in 2010 and 27% in 2012 are follow-on investments as compared to 44% in 2007. This could indicate that private equity firms lack the opportunities to sell their portfolio companies after the financial crisis, but surprisingly not in the postbubble years. Since IPO markets were similarly depressed between 2001 and 2003, we suspect that other underlying economic reasons are responsible for the observed growth in late stage VC.

In contrast to the surge in late stage VC deals, we can identify a marked decline in expansion investments. The proportion of investments aimed at expanding production to increase revenue, which can be made by both buyout firms and VC firms, was remarkably constant over the past 15 years. The number of such deals began to drop in 2007, followed by a drop in volume in 2010. Since expansion investments are strongly related to expected demand for the firm's products, this decline likely indicates increased uncertainty about future product market conditions.

Interestingly, early stage investments, but not seed investments, show resilience against the financial crisis and even improve their position as a proportion of all private equity deals. If long-term growth forecasts were unfavorable, we would expect investors to shy away from sponsoring early stage transactions. The relative volume of all early stage investments, however, did not experience similar growth, and seed investments recorded an even sharper negative trend. Seed and early stage investments are at low levels even compared to the postbubble years 2003 and 2004. The year 2010 saw the smallest proportion of seed/early stage VC deals by volume recorded over the last 15 years, and the following two years are not much better.

The quick recovery of buyout and acquisition volume supports the argument that private equity-financed companies (in particular, buyout investments) might be more resilient to crises because they must respond earlier to an unfavorable economic climate due to their higher debt burdens (Lerner, 2011). As a consequence, they adjust faster to new conditions and quickly regain momentum and produce positive returns when the economic environment stabilizes. Even if these companies face financial distress, it is often less severe than in other companies and can even lead to increased firm value (Andrade and Kaplan, 1998). Instead, early stage companies that are financed by equity or mezzanine instruments recover later from crises as the lack of debt on their balance sheets reduces the likelihood of financial distress and the necessity to react.

IV. Multivariate Analysis

A. Time Effects in a Liquidity Crisis

If the financial crisis can be seen as a liquidity crisis featuring high exit risk for VC investments, time effects during the crisis should capture its impact on the stage distribution of investments. We use logit models with year effects to isolate the crisis effect and to give us a benchmark for later comparisons with models that exclude year dummies in favor of macroeconomic explanatory variables. The logic is that time dummies are synthetic indicators that capture aggregate effects produced by variables (possibly unobserved) related to the macroeconomic environment, such as the number of IPOs or the level of interest rates. If we find that models including time series of

separate variables achieve a model fit close to that of the benchmark model with time dummies, we do not need to worry about omitted time effects and can focus on the interpretation of relevant environmental conditions.

A multivariate analysis controlling for deal characteristics supports the evidence shown in the descriptive analysis. Table III presents models for individual investment stages and a model for the early stages combined. As expected in Hypothesis H1, we find a positive time effect on the likelihood that a private equity investment is made in the early stage of the target's development. Liquidity as the hypothesized driving force behind variations in the stage composition is only partially supported, since we also note a negative effect on seed investment where we would expect a positive one. Even more surprisingly, the crisis effect on late stage investments is positive instead of negative, as would be expected if closed exit channels reduced the attractiveness of late stage VC investments. This finding casts doubt on liquidity risk as the main driver of late stage investments (Hypothesis H2). The liquidity theory profiled by Cumming et al. (2005) explains the larger number of early stage deals in periods of narrow exit channels, but would also predict fewer late stage investments. Conversely, stage drift due to negative market returns can explain the larger proportion of late stage deals, but not the increase in early stage investments. Both theories, liquidity and stage drift, have difficulties explaining the series of time effects in Table III. Wald tests confirm these differences in average coefficients in three-year periods before and during the financial crisis. As a robustness test, we estimate a multinomial logit model predicting all of the stages at once. This model confirms the results we find in the individual stage regressions.⁹

B. Liquidity or Technological Opportunities?

Instead of using time effects to estimate the impact of all changes in the macroeconomic environment combined, we can be more specific about potential factors driving the stage distribution of investments. We include information on the number of IPOs by European (EU27) firms to directly test the liquidity hypothesis and add the aggregate amount of R&D expenditures by European businesses, scaled by GDP, as a proxy for technological opportunities. To take into account the role of other structural determinants of private equity investments, we include indicators for product market sentiment, as well as equity and debt market conditions. Replacing time dummies with these variables increases the risk of unobserved heterogeneity in the time dimension and consequent biases. However, the log-likelihood of the models found in Table IV approaches the log-likelihood of models including time dummies. This makes us confident that our control variables capture most of the effects that would otherwise be subsumed under time effects.

Liquidity effects are reflected in the multivariate results of Table IV, but only to a certain extent. Not only seed and early stage investments, but also late stage VC investments react negatively to an increasing number of IPOs. If investors choose firms that are close to exit, we would expect a positive sign for late stage investments as the last investment round before an IPO.¹⁰ We find the same negative coefficient if we reduce the sample to include only early, late stage, and expansion investments (results not reported here, but available upon request). These effects are also economically significant. A one standard deviation increase in the (log) number of European IPOs decreases the proportion of VC investments, seed, early, and late stage deals, by

⁹ Results are available from the authors. Since single logit models are easier to interpret than multinomial ones due to the nonfixed reference category, we report only the results for individual logit models. Our interpretation of these results and, in particular, their standard errors and significance, is consistent with the results from a multinomial regression.

¹⁰ This is also the definition adopted by Thomson Reuters.

Table III. Likelihood of Stage Focus

This table presents results for logit models predicting the likelihood of an investment being made at the seed, early, late, expansion or acquisition stage. The dependent variable in the leftmost models is equal to one if the investment is in any of the two or three stage categories. Year dummies are relative to the base year, 1990, financing dummies use “missing” as the base category, and the intercept is not shown. “(2008+9+10) – (2005+6+7)” is the difference in the combined time effects before and during the financial crisis, followed by Wald test statistics. Heteroskedasticity-robust (Huber-White, HC3) standard errors are in parentheses.

Investment Stage	Seed & Early & Later	Seed & Early	Seed	Early Stage	Late Stage VC	Expansion	Acquisition
Age (log)	-0.679 (0.01)***	-1.004 (0.02)***	-0.868 (0.02)***	-0.532 (0.01)***	0.307 (0.02)***	0.037 (0.01)***	0.634 (0.02)***
Age n/a	-5.272 (0.12)***	-7.368 (0.16)***	-5.956 (0.16)***	-4.003 (0.12)***	1.616 (0.17)***	0.177 (0.08)**	5.510 (0.17)***
Deal Size (log)	-0.253 (0.01)***	-0.315 (0.01)***	-0.314 (0.02)***	-0.184 (0.01)***	-0.093 (0.02)***	-0.084 (0.01)***	0.609 (0.02)***
Investors (log)	0.175 (0.03)***	0.204 (0.03)***	0.044 (0.05)	0.252 (0.03)***	0.186 (0.05)***	0.085 (0.02)***	-0.070 (0.03)**
Equity	0.801 (0.03)***	0.611 (0.03)***	0.270 (0.05)***	0.632 (0.04)***	1.215 (0.06)***	0.736 (0.03)***	-2.341 (0.05)***
Debt	1.401 (0.09)***	-1.009 (0.14)***	-1.102 (0.20)***	-0.622 (0.16)***	3.441 (0.11)***	-0.070 (0.08)	-1.806 (0.13)***
Equity & Debt	0.658 (0.11)***	0.349 (0.13)***	0.307 (0.17)*	0.253 (0.15)*	1.244 (0.19)***	-0.077 (0.10)	-1.392 (0.12)***
Year 1991	-0.159 (0.36)	0.037 (0.40)	-0.662 (0.57)	0.353 (0.37)	-0.854 (0.87)	0.124 (0.30)	0.056 (0.40)
Year 1992	-0.124 (0.34)	-0.267 (0.39)	0.141 (0.50)	-0.397 (0.40)	0.571 (0.60)	0.019 (0.29)	0.490 (0.40)
Year 1993	0.216 (0.31)	-0.017 (0.35)	0.426 (0.45)	-0.275 (0.37)	0.905 (0.56)	-0.184 (0.29)	-0.125 (0.37)
Year 1994	-0.184 (0.31)	-0.334 (0.35)	0.353 (0.44)	-0.795 (0.39)**	0.512 (0.56)	0.122 (0.27)	0.038 (0.35)
Year 1995	-0.430 (0.31)	-0.495 (0.34)	-0.141 (0.45)	-0.569 (0.35)	0.114 (0.56)	0.403 (0.25)	-0.138 (0.34)
Year 1996	-1.108 (0.29)***	-1.440 (0.34)***	-0.975 (0.45)**	-1.251 (0.33)***	0.047 (0.51)	0.507 (0.23)**	0.699 (0.33)**
Year 1997	-0.614 (0.29)**	-0.838 (0.33)**	-0.237 (0.42)	-0.969 (0.33)***	0.173 (0.51)	-0.122 (0.24)	1.010 (0.32)***
Year 1998	-0.514 (0.27)*	-0.499 (0.30)	-0.273 (0.40)	-0.529 (0.30)*	-0.345 (0.50)	-0.207 (0.23)	0.894 (0.31)***
Year 1999	-0.359 (0.26)	-0.224 (0.29)	0.187 (0.38)	-0.467 (0.28)	-0.653 (0.49)	0.021 (0.22)	0.583 (0.30)*
Year 2000	-0.133 (0.26)	-0.008 (0.29)	0.348 (0.37)	-0.322 (0.28)	-0.535 (0.48)	0.195 (0.22)	-0.154 (0.30)

(Continued)

Table III. Likelihood of Stage Focus (Continued)

Investment Stage	Seed & Early & Later	Seed & Early	Seed	Early Stage	Late Stage VC	Expansion	Acquisition
Year 2001	-0.572 (0.26)**	-0.400 (0.29)	0.079 (0.37)	-0.534 (0.28)*	-0.942 (0.48)*	0.361 (0.22)	0.189 (0.30)
Year 2002	-0.762 (0.26)***	-0.529 (0.29)*	-0.197 (0.38)	-0.559 (0.28)**	-1.138 (0.50)**	0.478 (0.22)**	0.245 (0.30)
Year 2003	-0.040 (0.26)	0.108 (0.29)	0.305 (0.37)	-0.052 (0.28)	-0.312 (0.48)	0.468 (0.22)**	-0.385 (0.30)
Year 2004	-0.056 (0.26)	0.069 (0.29)	0.402 (0.37)	-0.176 (0.28)	-0.143 (0.48)	0.343 (0.22)	-0.137 (0.30)
Year 2005	-0.545 (0.26)**	-0.396 (0.29)	0.052 (0.38)	-0.600 (0.28)**	-0.510 (0.48)	0.112 (0.22)	0.528 (0.30)*
Year 2006	-0.593 (0.26)**	-0.260 (0.29)	0.433 (0.38)	-0.721 (0.28)**	-1.213 (0.49)**	0.062 (0.22)	0.854 (0.30)***
Year 2007	-0.293 (0.26)	-0.380 (0.29)	0.054 (0.38)	-0.614 (0.28)**	0.144 (0.48)	-0.757 (0.22)***	1.340 (0.30)***
Year 2008	0.229 (0.26)	-0.103 (0.29)	-0.092 (0.38)	-0.169 (0.28)	0.867 (0.48)*	-1.132 (0.23)***	1.076 (0.30)***
Year 2009	0.461 (0.26)*	0.153 (0.29)	-0.273 (0.39)	0.189 (0.28)	0.889 (0.48)*	-0.628 (0.23)***	0.567 (0.30)*
Year 2010	0.496 (0.26)*	0.091 (0.29)	-0.273 (0.39)	0.118 (0.28)	1.022 (0.48)**	-0.597 (0.22)***	0.561 (0.30)*
Year 2011	0.647 (0.26)**	0.373 (0.29)	-0.326 (0.38)	0.422 (0.28)	0.957 (0.48)**	-1.061 (0.22)***	0.822 (0.30)***
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(2008+9+10) – (2005+6+7)	2.617 395.7***	1.177 59.6***	-1.177 23.2***	2.071 149.1***	4.357 395.6***	-1.774 185.3***	-0.518 15.3***
Observations	35,240	35,240	35,240	35,240	35,240	35,240	35,240
Log-likelihood Null	-21,600	-19,470	-11,125	-14,616	-8,118	-22,562	-21,964
Log-likelihood Model	-17,947	-15,055	-8,820	-12,891	-6,733	-20,971	-15,644
Chi-squared test	0.000	0.000	0.000	0.000	0.000	0.000	0.000
McFadden R^2 (adj.)	0.167	0.224	0.202	0.114	0.164	0.068	0.285

*** Significant at the 0.01 level.

** Significant at the 0.05 level.

* Significant at the 0.10 level.

Table IV. Likelihood of Stage Focus with Macroeconomic Variables

This table presents results for logit models predicting the likelihood of an investment being made at the seed, early, late, expansion, or acquisition stage. The dependent variable in the leftmost models is equal to one if the investment is in any of the two or three stage categories. Time dummies are replaced by time series of aggregate variables: *IPOs Europe* is the (log) number of European initial public offerings, *VIX* is the CBOE volatility index divided by 100, *ESI* is the European Economic Sentiment Indicator divided by 100, *R&D/GDP* is the aggregate R&D spending for EU27 countries by GDP in percentage points, *UK Credit Spread* is the yield spread between 10-year UK gilts and UK 10-year corporate bonds from Datastream, and *UK Gov. Yield* is the yield on 10-year UK government gilts, both in percentage points. The lower panel presents specifications without the last four of these macroeconomic indicators. The intercept is not shown. Heteroskedasticity-robust (Huber-White, HC3) standard errors are in parentheses.

Investment Stage	Seed & Early & Later	Seed & Early	Seed	Early Stage	Late Stage VC	Expansion	Acquisition
Panel A. Main Regression Results							
Age (log)	-0.675 (0.01)***	-1.009 (0.02)***	-0.869 (0.02)***	-0.534 (0.01)***	0.317 (0.02)***	0.016 (0.01)*	0.653 (0.02)***
Age n/a	-5.238 (0.11)***	-7.409 (0.16)***	-5.985 (0.16)***	-4.019 (0.12)***	1.742 (0.17)***	-0.016 (0.08)	5.677 (0.16)***
Deal Size (log)	-0.242 (0.01)***	-0.302 (0.01)***	-0.300 (0.02)***	-0.177 (0.01)***	-0.089 (0.01)***	-0.074 (0.01)***	0.575 (0.02)***
Investors (log)	0.177 (0.03)***	0.206 (0.03)***	0.036 (0.05)	0.257 (0.03)***	0.198 (0.05)***	0.078 (0.02)***	-0.067 (0.03)**
Equity	0.731 (0.03)***	0.555 (0.03)***	0.219 (0.04)***	0.590 (0.04)***	1.117 (0.06)***	0.726 (0.03)***	-2.256 (0.05)***
Debt	1.257 (0.08)***	-1.065 (0.14)***	-1.095 (0.20)***	-0.701 (0.16)***	3.091 (0.10)***	-0.007 (0.08)	-1.695 (0.12)***
Equity & Debt	0.553 (0.11)***	0.293 (0.13)**	0.288 (0.17)*	0.186 (0.15)	1.037 (0.19)***	-0.013 (0.10)	-1.340 (0.12)***
IPOs Europe	-0.703 (0.06)***	-0.650 (0.07)***	-0.162 (0.09)*	-0.697 (0.08)***	-0.661 (0.13)***	0.355 (0.05)***	0.157 (0.07)**
R&D/GDP	7.786 (0.60)***	5.369 (0.67)***	0.145 (0.91)	6.627 (0.72)***	11.482 (1.09)***	-4.026 (0.51)***	-1.040 (0.66)
VIX	-1.082 (0.38)***	-0.714 (0.42)*	-1.469 (0.57)***	0.202 (0.48)	-2.297 (0.77)***	1.047 (0.31)***	-0.975 (0.40)**
ESI	5.748 (0.55)***	5.248 (0.60)***	2.688 (0.76)***	4.579 (0.68)***	5.586 (1.23)***	-5.234 (0.45)***	2.168 (0.59)***

(Continued)

7.1 percentage points, as measured by sample average marginal effects.¹¹ The deal class gaining the most from this reduction in VC investments is expansion investments with a 4.4 percentage point increase for the same change in liquidity. Thus, liquidity effects confirm the special role of late stage VC that is apparent in Figures 1 and 2.

Investors do not seem to follow the liquidity logic all the time. At least, it does not appear to be the main driver of late stage investments. A possible interpretation of this finding is that an impending IPO makes firms less likely to receive another round of VC. For example, investors facing adverse exit market conditions could provide further funding for late stage firms simply to keep them afloat until conditions improve. In his analysis of the staging decisions in VC, Gompers (1995) argues that firms that go public might quickly turn profitable and would need less funding instead of more. This argument is supported by the positive coefficient for expansion investments, which signals an increasing likelihood of these investments in favorable exit markets. Furthermore, age at investment in the late stage segment decoupled from the cyclical behavior seen in other VC and expansion investments and has been increasing since the dotcom period, suggesting structural problems in late stage VC. Under this alternative hypothesis, most investments in the “later stage” category in a hot issue market would be investments similar to early stage VC, which operates with a longer time horizon. Exaggerating for the sake of the argument, late stage investments could even be conceived of as the only investments that are not made in such a favorable environment.

The effect of technological opportunities on the stage distribution of investments appears to be strongest at the early stages of development. The effects of aggregate R&D expenditures are highly significant and economically substantial in our models for early stage and late stage VC. Investments in both stages react positively to higher R&D spending, while the likelihood of expansion investments relative to the other stages reacts negatively to increasing R&D expenditures. Interestingly, seed investments can only be weakly explained by macroeconomic variables, including liquidity and R&D, although the aggregate explanatory power of the other control variables is relatively high. If we compute and sort the average marginal effects for liquidity and technological opportunities for all of the stages, the implied stage order is {early, late, seed, acquisition, expansion} for increasing coefficients for liquidity and decreasing coefficients for technological opportunities. Thus, early stage and expansion stage investment seem to be the most sensitive to both market conditions.

When we interpret the relative statistical and economic significance of liquidity and technological opportunities in Table IV in light of Hypotheses H3 and H4, our findings do not support these predictions. In terms of statistical significance, the effect of liquidity on seed and early stage investments ($t = -9.57$ in Column “Seed & Early”) is slightly stronger than the effect of technological opportunities ($t = 8.06$). As such, Hypothesis H3 is not supported.¹² Equally surprising, the significance of liquidity ($t = -4.97$ in Column “Later Stage”) is much weaker for late stage VC than the effect of technological opportunities ($t = 10.53$). Average marginal effects as a measure for the economic significance of our explanatory variables mirror these results. The average likelihood for seed and early stage investments decreases by 5.3 percentage points for a one standard deviation change in the (log) number of IPOs, whereas a change of the same magnitude in R&D expenditures increases the likelihood of seed and early stage investments by 2.8 percentage points. For late stage investments, marginal effects for liquidity and R&D are -2.0

¹¹ Results for average marginal effects are available from the authors.

¹² However, use of standard errors clustered by year and industry in place of Huber-White standard errors ($t = -7.79$ for seed and early investments and $t = 5.41$ for late stage investments) brings these results more in line with the results presented in Section IV.C.

and 2.3 percentage points, respectively. In sum, although liquidity and technological opportunities appear as strong predictors of the stage distribution of VC, they do not support our predictions from a liquidity risk viewpoint.

C. Best Predictors of Investment Stage

The strength of an explanatory variable, such as liquidity or technological opportunities, can also be measured in terms of the variance explained in the dependent variable. Consequently, we can test Hypotheses H3 and H4 by using a goodness-of-fit index to assess the explanatory power of both variables. To estimate the power of each macroeconomic indicator in explaining the stage distribution of investments, we compare the goodness of fit in models including or excluding the variable in question. Likelihood-ratio tests then give an indication of the relative importance of these variables. The first set of models presented in Table V compares models that contain only one macroeconomic control variable at a time. The first three models extend the range of proxies for liquidity risk by the global number of IPOs and the number of global IPOs that are backed by private equity funds. The second panel of models is based on the models in Table IV, but drops one macroeconomic variable at a time. Again, a likelihood-ratio test measures the unique information contained in each variable.

In this analysis of investment stages, the explanatory power of technological opportunities dominates that of liquidity risk. For early, late stage, and expansion investments, R&D expenditures rank first or second in explanatory power if added to a model that excludes macroeconomic variables. They capture much of the environmental conditions that shape the stage distribution of investments and explain between 28% and 58% of the likelihood difference between models including and excluding time effects. Among the various IPO variables we consider, the number of European IPOs performs best in models for VC stages, but contributes much less than R&D to the model fit. The amount of unique information that is not contained in other macroeconomic variables can be tested by starting from a full model including all of the macroeconomic controls and dropping one of them at a time. We find that dropping liquidity or technological opportunities reduces model fit by the same order of magnitude. This suggests that both variables add unique information to our models, while R&D captures more additional environmental information.

In summary, we conclude that the empirical evidence partially supports Hypothesis H3 (the effect of technological opportunities on the likelihood of seed and early stage investments is stronger than the effect of exit opportunities). Hypothesis H4 (the effect of technological opportunities on the likelihood of late stage investments is weaker than the effect of exit opportunities) cannot be supported since technological opportunities improve model fit substantially more than liquidity. Even for expansion investments, which can be understood as investments in firms at a late stage of their development, technological opportunities outperform liquidity in terms of explanatory power.

Interestingly, a strong effect of liquidity does appear in acquisition investments, which are omitted in the study by Cumming et al. (2005). It is the number of private equity-backed IPOs however, and not the total number of IPOs, that explains the prevalence of these investments in some time periods. Additionally, their sensitivity to these international IPOs, as opposed to European IPOs, suggests that later stages react more strongly to global market conditions. The variable that carries the most unique information about acquisitions and expansions is the yield spread between corporate and government bonds. This measure can be seen as an indicator for risk in the credit market, upon which firms rely during the expansion and acquisition stages.

Table V. Model Fit for Individual Macroeconomic Variables

Panel A provides likelihood ratio tests that compare a reduced model (without IPOs, VIX, ESI, R&D, UK credit spread, and UK gov. yield time series) with a model in which these are added back one at a time without the other macroeconomic indicators. Panel B presents likelihood ratio tests for models in which macroeconomic variables are dropped one at a time from the full models in Table IV. In Panel C, we select the variable with the largest contribution to the likelihood in Panel A (except *IPOs Europe (scaled)* and *IPOs World (scaled)*), as these are estimated on a smaller data set) and compute the contribution of this variable to the reduced model relative to the model with time dummies in Table III. The model with time dummies represents the maximum likelihood that can be achieved by aggregate macroeconomic variables. *IPOs Europe* is the (log) number of European initial public offerings, *IPOs World (PE-backed)* is the (log) number of global initial public offerings that are backed by private equity funds, *IPOs World* is the (log) number of global initial public offerings, *VIX* is the CBOE volatility index divided by 100, *ESI* is the European Economic Sentiment Indicator divided by 100, *R&D/GDP* is the aggregate R&D spending for EU27 countries by GDP in percentage points, *UK Credit Spread* is the yield spread between 10-year UK gilts and UK 10-year corporate bonds from Datastream, and *UK Gov. Yield* is the yield on 10-year UK government gilts, both in percentage points. *Scaled* variables are scaled by the number of firms listed on European and international stock exchanges, respectively. Panel B reports likelihood ratio tests that compare a reduced model (without IPOs, VIX, ESI, R&D, and yield time series) with a model in which these are added back one at a time. Models designated by † are estimated on a dataset from 1996 to 2011.

Investment Stage	Seed & Early & Later	Seed & Early	Seed	Early Stage	Late Stage VC	Expansion	Acquisition							
	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.							
Panel A. Adding Variables Individually														
IPOs Europe	-18,388	102.3***	-15,251	20.1***	-8,900	14.9***	-13,080	74.1***	-7,122	158.5***	-21,770	8.4***	-16,224	42.7***
IPOs World (PE-backed)	-18,429	19.0***	-15,260	1.7	-8,907	0.4	-13,117	0.0	-7,187	28.3***	-21,651	245.2***	-16,121	249.3***
IPOs World	-18,437	4.1**	-15,261	0.0	-8,906	1.5	-13,115	4.0**	-7,195	12.6***	-21,726	95.1***	-16,186	117.4***
R&D/GDP	-18,178	520.4***	-15,185	152.9***	-8,903	8.1***	-12,987	261.4***	-6,992	418.4***	-21,565	417.6***	-16,240	10.2***
VIX	-18,366	146.3***	-15,254	14.7***	-8,894	25.4***	-13,083	69.5***	-7,094	213.7***	-21,679	190.1***	-16,239	13.2***

(Continued)

Table V. Model Fit for Individual Macroeconomic Variables (Continued)

Investment Stage	Seed & Early & Later	Seed & Early	Seed	Early Stage	Late Stage VC	Expansion	Acquisition							
	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.	Log-Lik. Chi-sq.							
Panel A. Adding Variables Individually														
ESI	-18,385	107.9***	-15,257	8.9***	-8,892	31.0***	-13,084	66.1***	-7,093	216.4***	-21,759	29.9***	-16,239	12.3***
UK Credit Spread	-18,313	251.4**	-15,248	25.5***	-8,897	19.9***	-13,081	73.4**	-7,029	343.0***	-21,548	451.4***	-16,214	63.1***
UK Gov. Yield	-18,315	247.7***	-15,207	108.3***	-8,907	0.0	-13,047	140.6***	-7,111	180.1***	-21,672	203.7***	-16,235	20.6***
IPOs Europe (scaled)†	-17,836	63.9***	-14,749	6.3**	-8,609	22.5***	-12,723	48.7***	-6,872	195.8***	-21,048	33.3***	-15,563	0.2
IPOs World (scaled)†	-17,867	1.6	-14,752	0.5	-8,621	0.0	-12,746	2.5	-6,966	7.8**	-21,036	58.7***	-15,517	93.5***
Panel B. Dropping Variables Individually														
IPOs Europe	-18,147	141.7***	-15,166	102.7***	-8,884	3.6*	-12,976	91.3**	-6,937	28.9***	-21,406	49.4***	-16,116	5.8**
R&D/GDP	-18,165	177.2***	-15,149	68.3***	-8,882	0.0	-12,973	85.5***	-6,978	111.2***	-21,411	59.9***	-16,115	2.9*
VIX	-18,081	8.6***	-15,116	3.1*	-8,885	6.9***	-12,930	0.2	-6,927	10.2***	-21,386	11.3***	-16,116	6.7***
ESI	-18,138	123.4***	-15,158	86.3***	-8,889	13.1***	-12,955	50.4***	-6,936	27.1***	-21,453	144.0***	-16,121	15.0***
UK Credit Spread	-18,104	56.2***	-15,117	4.1**	-8,882	0.7	-12,930	0.2	-6,962	80.5***	-21,539	316.7***	-16,201	176.1***
UK Gov. Yield	-18,093	32.8***	-15,135	41.0***	-8,883	2.6	-12,944	28.7***	-6,922	0.6	-21,392	22.4***	-16,115	4.1**
Panel C. Best Individual Fit														
Without aggregates	-18,439		-15,261		-8,907		-13,117		-7,201		-21,774		-16,245	
Including time dummies	-17,947		-15,055		-8,820		-12,891		-6,733		-20,971		-15,644	
Best model in Panel A	-18,178		-15,185		-8,892		-12,987		-6,992		-21,548		-16,121	
Log-Lik. diff. explained	0.529		0.370		0.178		0.576		0.447		0.281		0.207	
***Significant at the 0.01 level.														
**Significant at the 0.05 level.														
*Significant at the 0.10 level.														

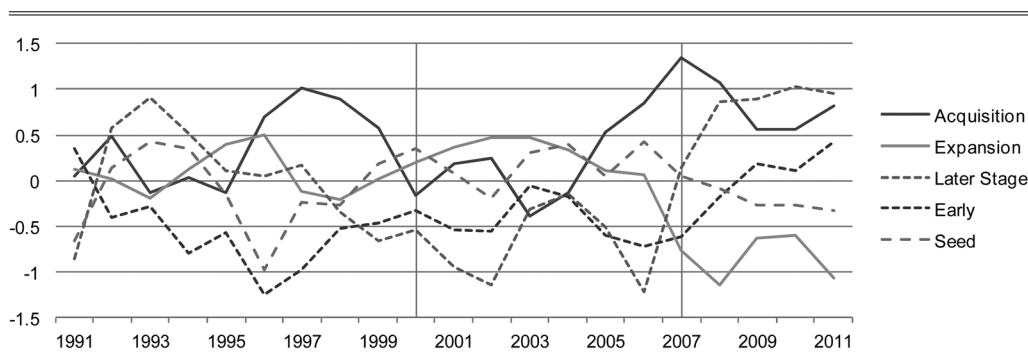
***Significant at the 0.01 level.

**Significant at the 0.05 level.

*Significant at the 0.10 level.

Figure 3. Time Effects in Multivariate Regressions of Firm Stage

This graph illustrates the time effects from regressions presented in Table III relative to the base year 1990. Vertical lines indicate the approximate end of boom periods.



V. The Stage Distribution after the Financial Crisis

What are the implications of the financial crisis for the VC investment model in Europe? During the crisis years of 2008 and 2009, several authors drew a gloomy picture for the future of the VC industry not only because of the dramatic changes in the macroeconomic framework, but also because of the weak returns recorded over the whole 2000-2010 period (Kedrosky, 2009; Mason, 2009; Lerner, 2011). In combination with large past inflows of capital, the tightening of exit channels creates a bottleneck in the VC cycle. Where capital is supposed to be invested, disinvested, distributed to limited partners, and then re-committed to new funds, resources are stuck in the investment phase of the cycle (Mason, 2009). The difficulty to produce cash flows from exits is aggravated by increasing IPO deal sizes, which are necessary to yield reasonable profits in the face of high transaction costs, and casts doubt on the VC business model.

A comparison between the dotcom period and the recent financial crisis can be useful when generating further insight into the reaction of VC markets to changes in the macroeconomic framework. The time effects in our regressions of investment stages demonstrate striking differences between the two shocks. Figure 3 presents a summary of the effects obtained in Table III. We find strong and highly significant negative time effects on expansion financing during the financial crisis, but positive ones for late stage investments. The opposite picture emerges during the dotcom period, which shows growth in expansion investments and a small decline in late stage investments. Interestingly, and similar to the univariate case, we find a positive time effect on early stage investments in recent years, but a negative effect on seed investments, while none of these effects can be detected during the dotcom period. The same picture emerges if we use models including environmental indicators (Table IV) plus a time dummy for the years 2010 and 2011. This time dummy yields estimates of the most recent time trend, which are consistent with an abnormal increase in late stage financings, more early stage investments, but fewer expansion and seed stage deals.

If investments in core VC stages (seed, early, and later stage) are grouped together, they perform above par after 2007. This is an important finding. The economic crisis does not appear to have had a negative effect on the likelihood of VC financing that is not already explained by deal-specific variables and macroeconomic indicators. In other words, the perceived lack of early

stage financing cannot be attributed to the financial crisis, but seems to be endogenous to the evolutionary development of the private equity market and might be a structural problem of the VC investment landscape. Note, however, that seed investments show an unstable negative coefficient, which might be a cause for concern. Moreover, the increasing proportion of late stage deals can be interpreted not as investors anticipating profitable exit opportunities, but as struggling start-ups in need of cash to ride out adverse product market conditions until profitability and exit channels improve.

Analyses using individual investments as their basic unit can reveal only part of the economic significance of recent trends. From a policy perspective, it is important to understand whether the next euro invested in private equity will be an early stage euro. Since the volume of capital flows may be more relevant for economic development than the number of investments, we perform a similar set of regressions of firm stage as in Table III, but weighted by deal size.

Results from the weighted regressions are presented in Table VI. Comparisons of time effects for the 2004-2007 and 2008-2011 periods confirm the positive effect of the crisis on early stage and late stage investments found in the unweighted analyses. The negative effect on expansion investments is, however, insignificant. These effects on early stage and late stage investments cannot be observed during the dotcom period. More investment in VC deals could mean that the VC business model is not broken and that good investments can still be made. However, the financial crisis may have made it harder for portfolio firms to achieve profitability before being sold in IPOs or trade sales, thus requiring more late stage money to survive the worst years. Reduced expansion investment similarly points toward a lack of demand and growth opportunities.

Regressions using time dummies to identify changes over time might still suffer from changes in unobserved variables that determine the stage focus of investments. A robustness test can be performed by matching postevent investments to similar investments in a short period prior to the financial crisis and comparing the stage distribution within these matched pairs. Therefore, we concentrate on two-year windows during the financial crisis and the dotcom bubble in order to limit the effect of unobserved heterogeneity over time.

Matching pre- and postcrisis investments confirms the earlier results presented in Table VI. We find more early and late stage financing in 2008 and 2009 as compared to the preceding two-year period, but fewer seed and expansion investments (see Table VII). When compared to the dotcom period, there is a strong increase in the number of early and late stage financing, in line with our earlier results (see Table VI). There is also evidence of an exceptionally weak climate for expansion investments during the financial crisis, a result that is found again in the low proportion of expansion investments weighted by deal size, reflecting worsening prospects for the growth of new firms after the financial crisis. In contrast to the dotcom bust period, seed and early stage investment did not suffer a setback. This result again indicates the limited impact of the financial crisis on the market for start-up capital.

VI. Robustness Checks and Extensions: The Role of Country Effects

Since macroeconomic time series tend to be correlated to a high degree, we test several alternative specifications to estimate the impact of collinearity among the explanatory variables used in the main estimations. Table IV (Panel B) presents specifications that include only IPOs and R&D expenditures either at the same time or individually, without other macroeconomic control variables. In both cases, the results are consistent with richer specifications. Including

Table VI. Likelihood of Stage Focus—Weighted by Deal Size

This table presents results for logit models predicting the likelihood of an investment being made at the seed, early, late, expansion or acquisition stage. The dependent variable in the leftmost model equals one if the investment is in any of the two stage categories. *Equity* and *debt* dummies are relative to the base category “equity and debt,” year dummies are relative to the base period 1990–1996. To ensure computational stability, time dummies had to be collapsed and Ireland was dropped from the sample. Weights are based on deal size and scaled to sum to the number of investments. Heteroskedasticity-robust (Huber-White, HC3) standard errors are in parentheses.

Investment Stage	Seed & Early & Later	Seed & Early	Seed	Early Stage	Late Stage VC	Expansion	Acquisition
Age (Log)	-0.435 (0.04)***	-0.785 (0.05)***	-0.770 (0.08)***	-0.571 (0.04)***	0.144 (0.06)**	-0.188 (0.05)**	0.321 (0.06)***
Age n/a	-3.614 (0.32)***	-5.536 (0.40)***	-4.828 (0.49)***	-4.278 (0.28)***	0.178 (0.57)	-1.074 (0.33)***	2.300 (0.51)***
Deal Size (Log)	-0.709 (0.04)***	-0.784 (0.05)**	-0.608 (0.08)***	-0.726 (0.04)***	-0.550 (0.05)**	-0.503 (0.09)**	0.687 (0.08)***
Investors (Log)	0.487 (0.08)***	0.546 (0.09)***	0.472 (0.15)***	0.534 (0.09)***	0.476 (0.15)***	0.460 (0.14)**	-0.302 (0.13)***
Equity	0.252 (0.29)	0.464 (0.38)	-0.076 (0.57)	0.923 (0.29)***	0.112 (0.40)	0.917 (0.30)***	-0.767 (0.34)**
Debt	1.585 (0.56)***	-1.969 (0.52)***	-2.304 (0.85)***	-1.283 (0.47)***	2.289 (0.58)***	0.204 (0.63)	-0.859 (0.56)
1997-2000	0.151 (0.34)	0.460 (0.45)	0.193 (0.67)	0.621 (0.29)**	-0.351 (0.45)	1.417 (0.18)**	-1.285 (0.25)***
2001-2003	-0.190 (0.35)	0.072 (0.45)	-0.287 (0.68)	0.357 (0.30)	-0.414 (0.49)	1.352 (0.20)**	-1.050 (0.26)***
2004-2007	-0.173 (0.33)	0.184 (0.44)	-0.147 (0.65)	0.362 (0.30)	-0.578 (0.42)	0.851 (0.19)**	-0.909 (0.33)***
2008-2011	0.892 (0.34)***	0.744 (0.46)	-0.591 (0.67)	1.184 (0.32)***	0.678 (0.41)	0.697 (0.36)*	-1.394 (0.30)***
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1997-2000 ≠ 2001-2003	3.825*	4.993**	2.632	3.805*	0.033	0.161	1.626
2004-2007 ≠ 2008-2011	76.528***	16.133***	5.954**	28.396***	53.001***	0.247	1.882
Observations	17,307	17,307	17,307	17,307	17,307	17,307	17,307
Log-likelihood Null	-5,738	-4,186	-1,782	-3,136	-2,765	-7,958	-11,051
Log-likelihood Model	-3,954	-2,609	-1,241	-2,126	-2,233	-6,169	-7,691
Chi-squared test	0.000	0.000	0.000	0.000	0.000	0.000	0.000
McFadden R ² (adj.)	0.291	0.354	0.276	0.324	0.183	0.230	0.250

***Significant at the 0.01 level.
**Significant at the 0.05 level.
*Significant at the 0.10 level.

Table VII. Financial Crisis versus Dotcom Bubble

This table presents proportions of deals in each stage category before and after two dates chosen to represent the beginning of the financial crisis (January 1, 2008) and the height of the dotcom bubble (March 10, 2000). Firms in a two-year period (Panel A) and a three-year period (Panel B) after each date are matched with firms in the preceding two- or three-year period first on industry, country, and type of capital received and then on a propensity score from probit regressions of the postcrisis/postbubble dummy on log(age), log(deal size), log(investors), type of capital, year, country, industry, and a missing value indicator for firm age. *t*-statistics are for average treatment effects for the treated observations. *N* is the number of treated observations in each subsample.

	Unweighted Proportions				Proportions Weighted by Deal Size			
	<i>N</i>	Treated	Control	<i>t</i> -Stat.	<i>N</i>	Treated	Control	<i>t</i> -Stat.
<i>Panel A. 2-Year Windows</i>								
<i>Financial Crisis</i>								
Seed & Early & Later	3,600	0.330	0.209	13.195***	1,707	0.143	0.177	-0.505
Seed & Early	3,600	0.200	0.169	3.818***	1,707	0.066	0.124	-1.086
Seed	3,600	0.050	0.075	-4.648***	1,707	0.013	0.078	-1.628
Early	3,600	0.150	0.094	7.960***	1,707	0.053	0.046	0.178
Later	3,600	0.130	0.040	14.199***	1,707	0.077	0.053	0.526
Expansion	3,600	0.179	0.259	-8.898***	1,707	0.158	0.433	-3.591***
Acquisition	3,600	0.439	0.492	-6.057***	1,707	0.634	0.352	3.406***
<i>Dotcom Bubble</i>								
Seed & Early & Later	5,841	0.366	0.376	-1.263	4,167	0.158	0.256	-2.597***
Seed & Early	5,841	0.339	0.343	-0.391	4,167	0.126	0.203	-2.240**
Seed	5,841	0.150	0.159	-1.450	4,167	0.046	0.083	-1.597
Early	5,841	0.190	0.184	0.887	4,167	0.080	0.120	-1.412
Later	5,841	0.027	0.034	-2.493**	4,167	0.032	0.053	-1.080
Expansion	5,841	0.450	0.390	6.915***	4,167	0.330	0.414	-1.754*
Acquisition	5,841	0.159	0.213	-8.786***	4,167	0.472	0.294	4.102***

(Continued)

Table VII. Financial Crisis versus Dotcom Bubble (Continued)

	Unweighted Proportions				Proportions Weighted by Deal Size			
	N	Treated	Control	t-Stat.	N	Treated	Control	t-Stat.
Panel B. 3-Year Windows								
Financial Crisis								
Seed & Early & Later	5,586	0.347	0.224	16.019***	2,826	0.118	0.065	1.211
Seed & Early	5,586	0.208	0.176	4.745***	2,826	0.050	0.030	0.709
Seed	5,586	0.048	0.075	-6.001***	2,826	0.008	0.009	-0.049
Early	5,586	0.159	0.101	9.772***	2,826	0.043	0.021	0.786
Later	5,586	0.140	0.048	17.308***	2,826	0.068	0.036	0.921
Expansion	5,586	0.200	0.299	-12.937***	2,826	0.109	0.212	-1.816*
Acquisition	5,586	0.407	0.430	-3.176***	2,826	0.684	0.683	0.016
Dotcom Bubble								
Seed & Early & Later	7,658	0.341	0.367	-3.601***	5,115	0.123	0.156	-0.785
Seed & Early	7,658	0.316	0.326	-1.465	5,115	0.099	0.128	-0.781
Seed	7,658	0.137	0.146	-1.535	5,115	0.035	0.043	-0.343
Early	7,658	0.179	0.181	-0.340	5,115	0.064	0.086	-0.674
Later	7,658	0.025	0.040	-6.002***	5,115	0.025	0.028	-0.153
Expansion	7,658	0.451	0.382	9.045***	5,115	0.274	0.377	-1.723*
Acquisition	7,658	0.180	0.228	-8.708***	5,115	0.569	0.437	2.268**

***Significant at the 0.01 level.

**Significant at the 0.05 level.

*Significant at the 0.10 level.

additional control variables renders coefficients on IPOs and R&D for the seed stage insignificant and more plausible. Additionally, the stage order implied by the marginal effects does not change.

A second robustness check is called for by the observation that government programs tend to invest in seed and early stage firms, which may bias our results if government responses to liquidity or technology shocks are different from that of other investors. As La Porta, Lopez-de-Silanes, and Shleifer (2008) note, civil law countries often rely more heavily on a state supply of financing and state investment companies to promote economic growth than common law countries. Thus, we repeat our regressions excluding 1,217 transactions that mention government affiliated programs as investors. All our main findings remain unchanged. Two small, but notable changes appear at the seed stage. We find a smaller effect of liquidity, which is now insignificant (previously significant at the 10% level) and a larger, but still insignificant effect (0.902) of technological opportunities.

Finally, the effects of liquidity and technological opportunities on the stage distribution of VC and private equity investments may be moderated by local institutions and legal frameworks. The effects of these factors may not be accurately captured by country dummies. Therefore, it is important to extend our analysis and take them into account in order to test the robustness of our results and uncover the presence of additional cross-country effects. Prior studies have found that legal frameworks affect capital markets' activities and economic growth (Levine, 1998, 2005). More specifically, corporate governance regimes can influence the cost of capital, firm performance, and the distribution of wealth between different stakeholders (La Porta et al., 2000, 2008; Gompers, Ishii, and Metrick, 2003). The cost of going public varies across countries and tends to be lower among countries with stronger legal frameworks (Shleifer and Wolfenzon 2002; Cumming, Fleming, and Schwienbacher, 2006). In addition, in private equity markets, VC control rights increase the likelihood that an entrepreneurial firm will exit by an acquisition, rather than through an IPO (Cumming, 2008), which suggests a differential impact of legal factors on VC investments and acquisitions. Investors employ fewer of these controls and veto rights and use common equity in countries of German legal origin, relative to Socialist, Scandinavian, and French legal origin (Cumming and Johan, 2008).

These economic effects of legal environments suggest a varying stage distribution of private equity investments across countries and potential interactions with other macroeconomic indicators such as liquidity in IPO markets. Countries with more developed capital markets usually have more IPOs, but efficient capital markets might also help investors to respond more quickly to fluctuations in liquidity. Similarly, differences in the government regulation of product or labor markets (e.g., the greater contractual flexibility of common law countries as in La Porta et al., 2008) can affect investors' ability to expand or contract R&D expenditures in response to the availability of profitable investments in technology. Additionally, investors may simply be more sensitive to technological developments in countries with high R&D activity.¹³ While the cross-sectional effects (i.e., main effects) of legal factors on the stage distribution of VC investments are captured by country dummies in our regressions, there is the potential for interaction effects that might not be captured in our model thus far.

Ideally, we would like to directly test for moderation effects through interaction terms that contain legal factors, such as anti-director rights, minority shareholder protection, or creditor rights (La Porta et al., 1998; Martynova and Renneboog, 2010) and liquidity or R&D. These interaction terms are highly correlated, however, with our time series for aggregate IPOs and R&D. Therefore, we classify countries according to legal origin and interact them with the number

¹³ Time averages of R&D/GDP for our sample period are 1.16% for countries of English legal origin, 0.93% for French legal origin, 1.54% for German legal origin, and 1.79% for Scandinavian countries.

Table VIII. Liquidity and Technological Opportunities by Country

This table presents the average marginal effects for logit models predicting the likelihood of an investment being made at the seed stage, early stage, or the late stage. In order to test country differences on the effects of liquidity and technological opportunities, we use interaction terms constructed from dummy variables for legal origin (groupings according to La Porta et al., 1998) and *IPOs Europe* and *R&D/GDP*, respectively. The model *Interaction Terms* includes these interaction terms. The models *Local Group* and *Incl. Aggregates* use the number of IPOs and business R&D expenditures specific to each of the four groups of countries. The variables *IPOs in Legal Group* and *R&D/GDP in Legal Group* are based on these group-specific time series. Countries with English legal origin are Ireland and the United Kingdom (the reference group omitted to avoid perfect collinearity). Countries with French legal origin are Belgium, France, Italy, the Netherlands, Portugal, Romania, and Spain. Countries with German legal origin are Austria, the Czech Republic, Germany, Hungary, Poland, and Switzerland. Countries with Scandinavian legal origin are Denmark, Finland, Norway, and Sweden. Results and variable definitions presented here correspond to those in Table IV. Standard errors are in parentheses.

	Seed & Early Stage			Later Stage		
	Interaction Terms	Local Group	Incl. Aggregates	Interaction Terms	Local Group	Incl. Aggregates
Age (log)	-0.139 (0.002)***	-0.138 (0.002)***	-0.139 (0.002)***	0.016 (0.001)***	0.016 (0.001)***	0.016 (0.001)***
Age n/a	-1.022 (0.017)***	-1.014 (0.017)***	-1.023 (0.017)***	0.089 (0.007)***	0.092 (0.007)***	0.090 (0.007)***
Deal Size (log)	-0.042 (0.002)***	-0.042 (0.002)***	-0.042 (0.002)***	-0.005 (0.001)***	-0.005 (0.001)***	-0.005 (0.001)***
Investors (log)	0.027 (0.004)***	0.029 (0.004)***	0.028 (0.004)***	0.011 (0.002)***	0.010 (0.002)***	0.010 (0.002)***
Equity	0.079 (0.004)***	0.072 (0.004)***	0.077 (0.004)***	0.057 (0.002)***	0.058 (0.002)***	0.058 (0.002)***
Debt	-0.105 (0.009)***	-0.107 (0.009)***	-0.106 (0.009)***	0.402 (0.021)***	0.406 (0.021)***	0.408 (0.021)***
Equity & Debt	0.048 (0.021)**	0.046 (0.021)**	0.044 (0.021)**	0.059 (0.015)***	0.059 (0.016)***	0.061 (0.016)***
IPOs Europe	-0.102 (0.010)***		-0.111 (0.010)***	-0.039 (0.005)***		-0.037 (0.005)***
IPOs in Legal Group		0.005 (0.004)	0.023 (0.004)***		-0.002 (0.002)	0.002 (0.002)
IPOs Europe × French	0.024 (0.009)***			0.008 (0.003)**		
IPOs Europe × German	0.016 (0.010)			0.015 (0.004)***		
IPOs Europe × Scandinavian	0.019 (0.010)*			0.009 (0.004)***		
R&D/GDP	0.286 (0.126)**		0.582 (0.096)***	0.321 (0.051)***		0.622 (0.039)***
R&D/GDP in Legal Group		0.217 (0.034)***	0.135 (0.034)***		0.019 (0.017)	-0.049 (0.015)***
R&D/GDP × French	0.466 (0.143)***			0.381 (0.058)***		
R&D/GDP × German	1.469 (0.164)***			0.054 (0.067)		
R&D/GDP × Scandinavian	-0.084 (0.167)			0.739 (0.072)***		
VIX	-0.077 (0.058)			-0.133 (0.026)***	0.048 (0.023)**	-0.112 (0.026)***
ESI	0.719 (0.080)***	-0.051 (0.049)	-0.104 (0.057)*	0.271 (0.038)***	0.037 (0.024)	0.287 (0.040)***
UK Credit Spread	0.008 (0.004)**	0.004 (0.004)	0.006 (0.004)	0.021 (0.002)***	0.016 (0.002)***	0.020 (0.002)***
UK Gov. Yield	-0.017 (0.003)***	-0.019 (0.002)***	-0.020 (0.003)***	-0.002 (0.001)	-0.012 (0.001)***	-0.001 (0.001)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	35,240	35,240	35,240	35,240	35,240	35,240
Log-likelihood	-15,057	-15,181	-15,092	-6,885	-6,998	-6,919
McFadden R^2 (adj.)	0.227	0.220	0.225	0.152	0.138	0.148

***Significant at the 0.01 level.

**Significant at the 0.05 level.

*Significant at the 0.10 level.

of IPOs and R&D expenditures. We report the results for the models that include interaction terms for the two most important stage classes in the context of this paper: seed and early stage VC and late stage VC.

Regressions for separate groups of countries reveal a number of differences in their sensitivity to IPO market conditions and R&D expenditures. The results in Table VIII suggest that seed, early, and late stage VC investors react most strongly to liquidity signals in countries with English legal origin. The proportion of these investments decreases less when liquidity improves in countries with legal systems of French, German, or Scandinavian origin (Columns “Interaction Terms”). This may be the reason why studies of the stage distribution of VC investments in the United States have found strong liquidity effects.

A reverse picture emerges for technological opportunities. Seed, early, and late stage investments in common law countries are least sensitive to changes in R&D expenditures across model specifications. There is no clear ranking, however, among French, German, and Scandinavian countries. For seed and early stage investment, the largest effects can be found in countries of German legal origin, while R&D effects on late stage VC are greatest for countries of French and Scandinavian legal origin. The strong common effect for liquidity and diverse effects for R&D suggest that the availability of technological developments might be more localized than exit channels for private equity investments.¹⁴

These results touch upon the important question whether investors react to local environmental conditions or respond, instead, to global signals. Although we cannot fully address this problem within the constraints of this paper, we find some evidence against the hypothesis of segmented markets. We test the segmentation hypothesis by measuring business R&D expenditures and IPOs in each group of countries. The results are presented in Table VIII, in the columns labeled “local group.” Liquidity loses its significance if data at the group level are used instead of the total number of European IPOs. R&D remains significant for seed and early stage investments, but loses economic significance for all VC investments. If we include aggregate European R&D and liquidity alongside local time series (Columns “Incl. Aggregates”), most of the economic and statistical significance is attributed to the aggregate variable, not the local one.¹⁵ These results support our choice of aggregate independent variables. More fine grained observations of legal variables could be used in future research and may reveal sharper contrasts across countries or different levels of sensitivity to global and local factors.

VII. Conclusion

This study addresses the theoretical problems of the role of exits in VC contracting (Black and Gilson, 1998; Aghion et al., 2004) and the determinants of the stage distribution of private equity investments (Gompers, 1995; Cumming et al., 2005, 2009). Its empirical contribution is an original analysis of the long-term development of European VC investments and their reaction to

¹⁴ We also examine the effects of legal origin by running separate regressions for each group of countries. The results, which are available upon request from the authors, are similar, but less precise due to estimation uncertainty related to smaller sample sizes. This favors the choice of the combined regression approach based on the interaction effects presented in Table VIII.

¹⁵ Further results (not reported here, but available upon request) indicate two distinct effects on VC investments: 1) a strong common effect of aggregate R&D and 2) a cross-sectional R&D effect that comes into force if country dummies are omitted from the regression. R&D itself is only weakly significant in most of the regressions, but if we decompose it into aggregate European R&D and an orthogonal residual component per country and year, both are highly significant if country dummies are excluded.

the post-2007 financial crisis, with a counterfactual analysis of the dotcom boom and bust period. We investigate how investors' choices of early versus late stage investments vary with the broader macroeconomic framework and identify drivers of the stage composition. Investment decisions are sensitive to liquidity risk and the availability of technological opportunities, but the effect of these factors varies across investment stages. Consistent with the liquidity risk theory, our results indicate that liquidity risk increases the probability of investing in earlier stages relative to all private equity investments. However, liquid exit markets also increase the proportion of late stage VC investments.

Liquidity risk alone is insufficient to explain the increased likelihood of late stage investments in recent years, and IPO market indicators can only partially predict the stage of investments. Overall, technological opportunities are a better explanatory variable than liquidity. We examine their effect in models that explicitly consider controls for the broader macroeconomic framework in which investments take place, including indicators for credit market risk, which are significant predictors of expansion and acquisition investments. These variables are often omitted in the prior research on investment staging. While liquidity, combined with credit risk, is the main driver of acquisition investments and, to some extent, of expansion financing, technological opportunities are by far the most powerful explanation of earlier stage investment choices.

With specific reference to the effects of the financial crisis, we find that VC funds invested at least as actively as other private equity funds, but caution against an optimistic interpretation of this finding. The trend of a decreasing number of VC investments after the dotcom boom reversed for early and late stage investments during the recent crisis. In these stages, the crisis does not appear to have had a negative effect on the likelihood of VC financing. However, we find strong and highly significant negative time effects on expansion financing during the financial crisis. Combined with the interpretation that late stage investments are made to keep firms afloat until exit markets become liquid, fewer expansion investments indicate an environment characterized by adverse demand conditions in firms' product markets.¹⁶

Despite extensive robustness checks, the paper has, of course, limitations and these indicate potential avenues for further research. Above all, we focus on investments as choices that imply valuations of expected returns, but we have not directly addressed the question of performance and its relation to the stage distribution and macroeconomic events. This question could be addressed at the fund or investment level. This analysis would also be able to address the role of different types of funds, and the relation between fund performance and local legal frameworks (Nahata, 2008; Cumming and Walz, 2010). A second and related question concerns fundraising and the long-term sustainability of the VC model (Mason, 2009; Lerner, 2011). Analyses of fundraising during the current recovery period and analyses of returns from funds invested during the financial crisis years will be especially important from a policy and a financial management perspective.

Overall, the outlook for European VC from an investor's viewpoint suggests disappointing growth rates with low, although increasingly stable, levels of investment volume.¹⁷ There might, however, be hope for the sector from a performance perspective. The pooled one-year internal rate of return of VC funds in Europe broke even in 2010 and increased to 9.9% in 2012.

¹⁶ In line with Cumming, Schmidt, and Walz (2010), it would be interesting to consider, through an extension of this analytical framework, whether there are differences between crisis and noncrisis periods, and between early and late stages, in the time it takes to make an investment. This could be addressed in follow-up studies.

¹⁷ Contrary to slowly growing late stage VC and buyout private equity, VC fundraising dropped to EUR 3.1 billion in 2011 according to Thomson ONE fundraising data and is stabilizing at this level, which was last seen in 2003. Uninvested capital, as a percentage of total capital committed to VC funds in Europe, has been decreasing constantly since the peak year 2000 and was at the lowest level on record at 24% in 2012. Not once over the past 20 years has uninvested capital dropped below 35%, but has usually fluctuated around the 40% mark.

Despite the difficult macroeconomic outlook, the VC model may be sound, as argued for the United States by Kaplan and Lerner (2010). Funds only need to keep on doing what they have always done; that is, connect entrepreneurs with good ideas, screen investments, design effective incentive schemes, and help companies through monitoring and guidance. Slow fundraising, but increasingly good returns could pave the way for a stable, albeit smaller, VC industry in Europe.

References

- Aghion, P., P. Bolton, and J. Tirole, 2004, "Exit Options in Corporate Finance: Liquidity versus Incentives," *Review of Finance* 8, 327-353.
- Aghion, P. and P. Howitt, 1992, "A Model of Growth Through Creative Destruction," *Econometrica* 60, 323-351.
- Andrade, G. and S. Kaplan, 1998, "How Costly is Financial (not Economic) Distress? Evidence from Highly Leveraged Transactions that Become Distressed," *Journal of Finance* 53, 1443-1493.
- Ang, A.A., R.J. Hodrick, Y. Xing, and X. Zhang, 2006, "The Cross-Section of Volatility and Expected Returns," *Journal of Finance* 61, 259-299.
- Baker, M. and J. Wurgler, 2007, "Investor Sentiment in the Stock Market," NBER Working Paper 13189.
- Black, B. and R.J. Gilson, 1998, "Venture Capital and the Structure of Capital Markets: Banks versus Stock Markets," *Journal of Financial Economics* 47, 243-277.
- Breschi, S., F. Malerba, and L. Orsenigo, 2000, "Technological Regimes and Schumpeterian Patterns of Innovation," *Economic Journal* 110, 388-410.
- Campbell, J.Y. and L. Hentschel, 1992, "No New is Good News – An Asymmetric Model of Changing Volatility in Stock Returns," *Journal of Financial Economics* 31, 281-318.
- Caselli, S., S. Gatti, and F. Perrini, 2009, "Are Venture Capitalists a Catalyst for Innovation?" *European Financial Management* 15, 92-111.
- Chan, Y., 1983, "On the Positive Role of Financial Intermediation in Allocation of Venture Capital in a Market with Imperfect Information," *Journal of Finance* 38, 1543-1568.
- Cohen, W.M., 2010, "Fifty Years of Empirical Studies of Innovative Activity and Performance," in B.H. Hall and N. Rosenberg, Eds., *Handbook of the Economics of Innovation*, Vol. 1, Amsterdam, Elsevier, 129-213.
- Cohen, W.M. and R.C. Levin, 1989, "Empirical Studies of Innovation and Market Structure," in R. Schmalensee and R. Willig, Eds., *Handbook of Industrial Organization*, Amsterdam, Elsevier, 1059-1107.
- Cohen, W.M., R.C. Levin, and D.C. Mowery, 1987, "Firm Size and R&D Intensity: A Re-examination," *Journal of Industrial Economics* 35, 543-563.
- Cohen, W.M. and D.A. Levinthal, 1989, "Innovation and Learning: The Two Faces of R&D-Implications for the Analysis of R&D Investment," *Economic Journal* 99, 569-596.
- Cornelli, F. and O. Yosha, 2003, "Stage Financing and the Role of Convertible Debt," *Review of Economic Studies* 70, 1-32.
- Cumming, D.J., 2008, "Contracts and Exits in Venture Capital Finance," *Review of Financial Studies* 21, 1947-1982.

- Cumming, D.J., G. Fleming, and A. Schwienbacher, 2005, "Liquidity Risk and Venture Capital Finance," *Financial Management* 34, 77-105.
- Cumming, D.J., G. Fleming, and A. Schwienbacher, 2006, "Legality and Venture Capital Exits," *Journal of Corporate Finance* 12, 214-245.
- Cumming, D.J., G. Fleming, and A. Schwienbacher, 2009, "Style Drift in Private Equity," *Journal of Business Finance and Accounting* 36, 645-678.
- Cumming, D.J. and S.A. Johan, 2008, "Preplanned Exit Strategies in Venture Capital," *European Economic Review* 52, 1209-1241.
- Cumming, D.J., D. Schmidt, and U. Walz, 2010, "Legality and Venture Capital Governance Around the World," *Journal of Business Venturing* 25, 54-72.
- Cumming, D.J. and U. Walz, 2010, "Private Equity Returns and Disclosure Around the World," *Journal of International Business Studies* 41, 727-754.
- Denis, D.J., 2004, "Entrepreneurial Finance: An Overview of the Issues and Evidence," *Journal of Corporate Finance* 10, 301-326.
- Dosi, G., 1988, "Sources, Procedures, and Microeconomic Effects of Innovation," *Journal of Economic Literature* 26, 1120-1171.
- EVCA, 2012, *EVCA Yearbook 2012*, European Venture Capital and Private Equity Association, Available at: <http://www.evca.eu/knowledgecenter/statisticsdetail.aspx?id=6392>.
- EVCA, 2013, *EVCA Yearbook 2013*, European Venture Capital and Private Equity Association, Available at: <http://www.evca.eu/knowledgecenter/statisticsdetail.aspx?id=6392>.
- Fagerberg, J., D.C. Mowery, and R.R. Nelson, 2005, *The Oxford Handbook of Innovation*, Oxford, UK, Oxford University Press.
- Fama, E.F. and K.R. French, 1993, "Common Risk Factors in the Returns on Stocks and Bonds," *Journal of Financial Economics* 33, 3-56.
- Geroski, P.A., 1990, "Innovation, Technological Opportunity, and Market Structure," *Oxford Economic Papers* 42, 586-602.
- Gompers, P., 1995, "Optimal Investment, Monitoring, and the Staging of Venture Capital," *Journal of Finance* 50, 1461-1489.
- Gompers P., J. Ishii, and A. Metrick, 2003, "Corporate Governance and Equity Prices," *Quarterly Journal of Economics* 118, 107-156.
- Gompers, P., A. Kovner, J. Lerner, and D. Scharfstein, 2008, "Venture Capital Investment Cycles: The Impact of Public Markets," *Journal of Financial Economics* 87, 1-23.
- Gompers, P. and J. Lerner, 1999, "What Drives Venture Capital Fundraising?" NBER Working Paper No. 6906.
- Gompers, P. and J. Lerner, 2000, "Money Chasing Deals? The Impact of Fund Inflows on Private Equity Valuations," *Journal of Financial Economics* 55, 281-325.
- Griliches, Z., 1979, "Issues in Assessing the Contribution of Research and Development to Productivity Growth," *Bell Journal of Economics* 10, 92-116.
- Grossman, G.M. and E. Helpman, 1991, *Innovation and Growth in the Global Economy*, Cambridge, MA, MIT Press.

- Hahn, J. and H. Lee, 2006, "Yield Spreads as Alternative Risk Factors for Size and Book-to-Market," *Journal of Financial and Quantitative Analysis* 41, 245-269.
- Hellmann, T., 1998, "The Allocation of Control Rights in Venture Capital Contracts," *RAND Journal of Economics* 29, 57-76.
- Jaffe, A.B., 1986, "Technological Opportunity and Spillovers of R&D," *American Economic Review* 76, 984-1001.
- Jaffe, A.B., 1988, "Demand and Supply Influences on R&D Intensity and Productivity Growth," *Review of Economics and Statistics* 70, 431-437.
- Jeng, L.A. and P.C. Wells, 2000, "The Determinants of Venture Capital Funding: Evidence Across Countries," *Journal of Corporate Finance* 6, 241-289.
- Kaplan, S.N. and J. Lerner, 2010, "It Ain't Broke: The Past, Present, and Future of Venture Capital," *Journal of Applied Corporate Finance* 22, 36-47.
- Kaplan, S.N. and A. Schoar, 2005, "Private Equity Performance: Returns, Persistence and Capital," *Journal of Finance* 60, 1791-1823.
- Kaplan, S., B. Sensoy, and P. Strömberg, 2002, "How Well Do Venture Capital Databases Reflect Actual Investments?" University of Chicago Working Paper.
- Kaplan, S. and P. Strömberg, 2001, "Venture-Capitalists as Principals: Contracting, Screening, and Monitoring," *American Economic Review* 91, 426-430.
- Kedrosky, P., 2009, "Right-Sizing the US Venture Capital Industry," *Venture Capital* 11, 287-293.
- Klevorick, A.K., R. Levin, R.R. Nelson, and S. Winter, 1995, "On the Sources and Significance of Interindustry Differences in Technological Opportunities," *Research Policy* 24, 195-205.
- Kline, S.J. and N. Rosenberg, 1986, "An Overview of Innovation," in R. Landau and N. Rosenberg, Eds., *The Positive Sum Strategy*, Washington, DC, National Academy Press.
- Kortum, S. and J. Lerner, 2000, "Assessing the Contribution of Venture Capital to Innovation," *RAND Journal of Economics* 31, 674-692.
- Kurov, A., 2010, "Investor Sentiment and the Stock Market's Reaction to Monetary Policy," *Journal of Banking and Finance* 34, 139-149.
- La Porta, R., F. Lopez-de-Silanes, and A. Shleifer, 2008, "Economic Consequences of Legal Origins," *Journal of Economic Perspectives* 46, 285-332.
- La Porta, R., F. Lopez-de-Silanes, A. Shleifer, and R. Vishny, 1998, "Law and Finance," *Journal of Political Economy* 106, 1113-1155.
- La Porta, R., F. Lopez-de-Silanes, A. Shleifer, and R. Vishny, 2000, "Investor Protection and Corporate Governance," *Journal of Financial Economics* 58, 3-27.
- Lerner, J., 1995, "Venture Capitalists and the Oversight of Private Firms," *Journal of Finance* 50, 301-318.
- Lerner, J., 2011, "The Future of Private Equity," *European Financial Management* 17, 423-435.
- Levine, R., 1998, "The Legal Environment, Banks, and Long-Run Economic Growth," *Journal of Money, Credit, and Banking* 30, 688-726.
- Levine, R., 2005, "Finance and Growth: Theory and Evidence," *Handbook of Economic Growth*, Vol. 1, Part A, Amsterdam, Elsevier, 865-934.

- Maats, F., A. Metrick, A. Yasuda, B. Hinkes, and S. Vershovski, 2008, "On the Consistency and Reliability of Venture Capital Databases," University of Pennsylvania Working Paper.
- Martynova, M. and L. Renneboog, 2010, "A Corporate Governance Index: Convergence and Diversity of National Corporate Governance Regulations," Tilburg University, CentER Discussion Paper No. 2010-17.
- Mason, C.M., 2009, "Venture Capital in Crisis?" *Venture Capital* 11, 279-285.
- Meggison, W. and K. Weiss, 1991, "Venture Capitalist Certification in Initial Public Offerings," *Journal of Finance* 46, 879-903.
- Nahata, R., 2008, "Venture Capital Reputation and Investment Performance," *Journal of Financial Economics* 90, 127-151.
- Nelson R.R. and S. Winter, 1982, *An Evolutionary Theory of Economic Change*, Cambridge, MA, Harvard University Press.
- Nieto, M. and P. Quevedo, 2005, "Absorptive Capacity, Technological Opportunity, Knowledge Spillovers, and Innovative Effort," *Technovation* 25, 1141-1157.
- Olsson, O., 2005, "Technological Opportunity and Growth," *Journal of Economic Growth* 10, 35-57.
- Romer, P.M., 1990, "Endogenous Technological Change," *Journal of Political Economy* 98, S71-102.
- Rosenberg, N., 1974, "Science, Invention, and Economic Growth," *Economic Journal* 84, 90-108.
- Sahlman, W., 1990, "The Structure and Governance of Venture Capital Organizations," *Journal of Financial Economics* 27, 473-521.
- Scherer, F.M., 1965, "Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions," *American Economic Review* 55, 1097-1125.
- Schumpeter, J.A., 1934, *The Theory of Economic Development*, Cambridge, MA, Harvard University Press.
- Shane, S. and S. Venkataraman, 2000, "The Promise of Entrepreneurship as a Field of Research," *Academy of Management Review* 25, 217-226.
- Shleifer, A. and D. Wolfenzon, 2002, "Investor Protection and Equity Markets," *Journal of Financial Economics* 66, 3-27.
- Simon, D.P. and R.A. Wiggins III, 2001, "S&P Futures Returns and Contrary Sentiment Indicators," *Journal of Futures Markets* 21, 447-462.
- Trajtenberg, M., 1990, *Economic Analysis of Product Innovation – The Case of CT Scanners*, Cambridge, MA, Harvard University Press.
- Ueda, M., 2004, "Banks versus Venture Capital: Project Evaluation, Screening, and Expropriation," *Journal of Finance* 59, 601-621.
- Weitzman, M.L., 1998, "Recombinant Growth," *Quarterly Journal of Economics* 113, 331-360.
- Whaley, R.E., 2000, "The Investor Fear Gauge," *Journal of Portfolio Management* 26, 12-17.